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A behavioural approach for seismic risk mitigation

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ABSTRACT Earthquake is a natural calamity that cannot be predicted, and even though one day, hypothetically, this might be possible, its occurrence will not anyhow be avoided. Its unpredictability, together with its inescapability, poses the accent on preparedness and prevention, which represent the sole activities that can be pursued in order to mitigate its catastrophic effects. Within this scenario, human behaviour becomes extremely relevant. Two main actors of seismic risk mitigation are especially important: the population and the policy-makers, the latter in charge of safety and protection of the civil community. Contrary to a rational calculus, which would like people to protect themselves more and more as risk increases, we observe instances of inefficient behaviours, dictated to a large extent by the cognitive strategies with which people deal with when making decisions in the domain of seismic risk. Moreover, this expectation is largely unattended, because of the controversial behaviours and different perspectives of the two actors in dealing with seismic risk. The paper approaches the problem through the tools of behavioural economics, trying to investigate possible cognitive biases and risk misperception which can trigger crowding out either of individuals or policy-makers for undertaking seismic risk reduction measures, with the final goal of supporting and improving the effectiveness of risk reduction strategies designed at governmental level. A particular focus is dedicated to Italy, as being a country with high seismic risk and, on the other hand, significant skills on seismic risk reduction strategies.

Key words: seismic risk prevention, cognitive biases, heuristic reasoning, decision making.

1. Introduction

"[…] If earthquakes are among the most destructive of natural disasters, then a "rational model" would suggest that all people living in recognized zones of high seismic risk would be aware of the hazard, accept the possibility of damages, and take all possible precautions to minimize the impact of future events. […] However, response to earthquake hazard shares none of these expected characteristics" (Jackson, 1981).

This consideration was made in 1981 by a professor of Geography from the University of Alberta and, already at the time, highlighted the controversial behaviour of human beings in adopting self-protecting measures despite their exposure to such an insidious type of hazard. The rational model mentioned by Jackson (1981) is the one typically associated with the

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homo economicus, defined since the 19th century by the classical economic theory: consistently rational and narrowly self-interested agent, who usually optimally pursues his subjectively-defined ends (Mill, 1904). Over the last forty years, this approach was gradually challenged by a different branch of economics, known as Behavioural Economics, examining under a different light the actual economic behaviour of human beings, comprising widespread deviations from the rational economic agent, including human cooperation and altruism. Consistent with this approach, economical agents, and then human beings, rather than being characterised by pure rational behaviour, are featured by limited rationality, whose model typically integrates insights from psychology, neuroscience, and microeconomic theory.

According to a bounded rationality model, when individuals make decisions, their rationality is limited by the tractability of the decision problem, the cognitive limitations of their minds, and the time available to make the decision (Simon, 1957; Simon and Newell, 1972). Decision-makers in this view act seeking a satisfactory solution rather than an optimal one. Nobel laureate, Herbet Simon's view of the cognitive limitations of human reasoning, and the adoption of a satisfactory - rather than optimal - solution, has been more recently reinterpreted within the paradigm of cognitive sciences (Thaler and Sunstein, 2008; Kahneman, 2012). Within this paradigm, humans are irrational by necessity, but can adopt a more analytical reasoning if they have enough cognitive resources, enough motivation, all the information available and perfect feedback (Thaler and Sunstein, 2008). However, such a magical combination, rarely occurs. Human reasoning is especially affected when dealing with decision-making processed under risk and uncertainty, such as natural disasters evoked by Jackson (1981). In this scenario characterised by a low probability of occurrence and a high severity of damage, the explicit reference to concepts such as risk and probability, and the necessity to process difficult numerical computations, make it even more likely for individuals to adopt simple rules of thumb, when dealing with such a complex issue.

In order to reduce the complex tasks of assessing probabilities and predicting values to simpler judgmental operations, individuals mostly rely on heuristic principles (Tversky and Kahneman, 1974; Kahneman *et al.*, 1982). Heuristics provide easy and rapid approaches to problem solving, learning, or discovery, that employs a practical method not guaranteed to be optimal or perfect, but pretty sufficient for the immediate or daily goals. Heuristics are mental shortcuts that ease the cognitive load of making a decision, implying intuitive judgments, rule of thumb, educated guess, and empirical knowledge. Although generally effective and useful in the daily life, sometimes they lead to severe and systematic errors, termed "cognitive bias" (Tversky and Kahneman, 1974). According to a different and more optimistic view, heuristics are special tools that tackle specific tasks under conditions of uncertainty, and are organized in an adaptive toolbox on which both individuals and organizations rely in an adaptive way (Gigerenzer, 2002).

This heuristic reasoning is expression of a precise experiential cognitive process, also known as System 1, while an analytical process is associated to a different system, System 2, according to a dual cognitive functioning of the brain early described by Stanovich and West (2000) and later on by Kahneman (2012). According to this model, System 1 operates automatically and quickly, with little or no effort and no sense of voluntary control, though often relying on emotional stimulus, like "affect" (Slovic, 1997; Slovic *et al.*, 2002). System 2 allocates attention to the effortful mental activities that demand it, including complex computations. Moreover, while the first system is fast, largely unconscious, intuitive and emotional, the second is slower, more deliberative and logical. An example of System 1 thinking is detecting that one object is more

distant than another, while an example of System 2 thinking is parking in a narrow space. Human judgment and decision-making rely on these two systems to make decisions under uncertainty, using one of the two according to the demands of the situation and the status of the individual.

Among the heuristics used to compute probability judgments, the best known are the "representativeness"s and "availability heuristics". The first (representativeness) leads to a probability inference by rapidly assessing the similarity of the target object to the prototype of the belonging class; if the target object is similar (representative of) to the prototype of the belonging class, then the probability is judged high. The second (availability) is a mental shortcut that occurs when people make judgments about the probability of events by the ease with which examples come to mind (Tversky and Kahneman, 1974; Kahneman, 2012). The judgment of individuals on how likely they are, or less, to be subject to seismic risk is, inevitably, the result of a heuristic reasoning that uses one, or both, of the two heuristics.

Experimental research in the field of cognitive sciences also outlined that people are strongly influenced by how information is presented or framed (Levin *et al*., 1998), as being their attention much more captured when the information is vivid or salient rather than represented by statics or figures (Sunstein, 2013). Decision making in risky situations is also characterised by loss aversion, a strong binding force that discourages any life change by making individuals perceive potential losses much worse than potential gains (Tversky and Kahneman, 1981). Moreover, people show unrealistic optimism so that they believe that they will be less likely than others to suffer from various misfortunes, leading to personal risk underestimation in most cases (Weinstein, 1980).

Preference and attitudes of individuals in the decisional process under uncertain situations do not solely depend on their misperception of likelihood of events. Research suggests that emotions and affect are also a crucial orienting mechanism that directs fundamental psychological processes such as attention, memory, and information processing (Slovic, 1997; Slovic *et al*., 2002). This mechanism could help to explain, to make an example, some of the behaviours often encountered in the aftermath of catastrophic events.

Further typical behaviours of individuals typically affecting the decisional process, also in undertaking protective measures, is the preservation of the *status quo*, implying decision procrastination (Samuelson and Zeckhauser, 1988; Thaler and Sunstein, 2008). More generally, people may decline to change from the *status quo* even if the costs of change are low and benefits are substantial. This attitude can have very adverse effects on regulatory processes and risk protection attitudes (Sunstein, 2003; Thaler and Sunstein, 2008). Moreover, it is strictly correlated to the difficulty in processing decisions whose effects are temporally delayed, like in the case of preventive measures against natural risks subjected to intertemporal choices, one of the main topic struggling economists and behavioural scientists over the last years (Lowenstein and Thaler, 1989; Berns *et al.*, 2007).

Last but not least, social norms, defined by informal understandings that govern the behaviour of members of a society spontaneously developed among individuals characterised by normative expectations, are crucial orienting mechanism in the decisional process related to risk prevention (Bicchieri, 2006). People care about their reputation and for this reason their conduct is influenced by others in order to obtain their approval. In some contexts social norms can strongly influence people believes and attitudes also when the high stake is protection against risks. What happens is that when regulatory policies are in contrast with these norms, their achievement can be seriously threatened, and crowding behaviours are often observed. On the other hand, social norms

can represent a powerful tool for creating a phenomenon of compliance without enforcement (Sunstein, 2013; Sunstein and Hastie, 2014).

The issue of how people and decision makers deal with risk, more specifically natural risks, and either decide or not decide to undertake protective measures for themselves and for the people they are responsible, is a very complex and subtle task. In fact, most of the heuristics and biases such as "loss aversion, unrealistic optimism, the availability heuristics and social influences are simultaneously at work and will point in different directions, making predictions difficult or impossible. For example, unrealistic optimism may lead people to underestimate certain risks, while the availability heuristics may lead people to overestimate the same risks. And although procrastination will cause delay, loss aversion may lead people to act promptly" (Sunstein, 2013). This means that every situation needs to be analysed specifically in order to make predictions on behaviours more reliable. This is the main task of this work, whose goal is narrowed to prevention and preparedness phase related to low-probability occurrence and high-consequence natural events, such as earthquakes.

A contribution addressing behavioural aspects of human decision making in the field of seismic risk has been recently published (Di Bucci and Savadori, 2017) which investigates on a wide spectrum how the acceptable risk level is being determined in political decisions and related policies in the field of civil protection, i.e. regarding disaster risks and their reduction at different political and institutional levels over the entire risk cycle (prevention, prevision, emergency response, and recovering). This contribution identifies several cognitive mechanisms that impede the decision of an acceptable level of seismic risk at the political level.

How cognitive reasoning in decision making can influence citizens' choices related to natural disasters has been thoroughly examined (Meyer and Kunreunther, 2017). The authors identify six main biases that lead individuals, communities and institutions to underprepare for disasters, sometimes at cost of their lives. On this ground they also suggest a systematic approach for improving preparedness by recognising these bias and design strategies to anticipate them. This work provides a valid framework to further investigate in more detail, under a behavioural approach, some mechanisms specifically related to seismic risk mitigation, which is the aim of this contribution. This unusual point of view is possible thanks to the different scientific and institutional backgrounds of the authors pertaining to behavioural economics and seismic risk respectively. More specifically, the direct experience matured by some of the authors within the Italian Civil Protection Department, offers a concrete basis to discuss some typical behaviours observed in a seismic prone country such as Italy, featured by active and long-lasting prevention efforts prompted by the government (Dolce, 2012).

This paper is organised as follows. First, issues related to the implementation of seismic risk mitigation strategies are briefly discussed. Then, these issues are analysed with the tools of behavioural economics. Six main psychological mechanisms are then recognised to exert a major role in affecting decision-making processes at individual or group level when dealing with seismic risk and hence particularly able to hinder people and local public administrations by undertaking seismic prevention measures.

In the authors' opinion the recognition of these mechanisms is an initial important step for achieving a more comprehensive strategy, at institutional level, to increase seismic awareness of individuals and decision making, so as to provide positive enforcement to seismic risk mitigation policies and finally increase resilience of communities.

2. The dichotomy of risk in civil society

Before stepping forward, a clarification on risk and uncertainty will help for a better understanding of further dissertation. The two concepts, show different *nuances* depending on the specific field of application (finance, insurance, work, daily life, extreme situations), including natural disasters (Di Bucci and Savadori, 2017). Moreover, in the popular understanding their meanings are somewhat assimilated and generically associated to the idea of chance or possibility.

Early definitions or risk and uncertainty can be found since Renaissance period onwards (Cardano, 1525; Bernoulli, 1738), although an autonomous research branch was addressed only in the 19th century. In fact, the former scientific definition of risk goes back to 1921 when the economist Knight (1921) attempted a distinction between the two concepts, by associating risk with quantities susceptible of measurements, whilst uncertainty with unmeasurable quantities. Present-day official definitions are provided by the International Organization for Standardization publication ISO 31000 (ISO Guide 73, 2009). This defines risk as the effect of uncertainty on objectives. The definition includes both negative and positive impacts. In this definition, uncertainties, include events which may or may not happen depending on their quantifiable likelihood, while uncertainties are caused by ambiguity or a lack of information (usually known as epistemic uncertainty).

With specific reference to natural risks, the United Nations Office for the Disaster Risk Reduction provides a net distinction between the concept of risk and disaster risk, by associating to the latter the concept of potential losses in terms of lives, health, status, livelihoods, assets, and services which a given community might be involved in, following a catastrophic event (UNISDR, 2009). In fact, coherently with Sendai Framework aims which was adopted by U.N. Member States in 2015, human losses are among the most important risk indicators and their reduction is the ultimate goal of disaster risk mitigation policies at the international level.

In this process a crucial step is represented by risk assessment, as defined by the overall process of risk identification, risk analysis, and risk evaluation according to ISO 31000 (ISO Guide 73, 2009); definitions and E.U. guidelines (European Commission, 2010). When specifically related to natural disasters, the definition of risk requires technical evaluations, embedded in the risk analysis phase, as being risk a function of the probability of occurrence of a hazard, the exposure (total value of all elements at risk), and the vulnerability (specific impact on exposure) (European Commission, 2010), as also highlighted by Di Bucci and Savadori (2017).

The extreme complexity associated with risk formulation, especially in the field of natural hazards, determines this field being strictly limited to very few people, capable to understand the physical phenomenon and, on the other hand, the probability calculation (Erto *et al.*, 2012). This also explains why risk analysis, being the intermediate step in risk assessment process, is typically demanded to the scientific community, better known (in the behavioural literature) as "experts". Results of risk analysis are supposed to be handed to decision makers responsible of the further risk evaluation process, aimed at deciding the acceptability of the risk itself, whose scope is beyond the purpose of this work.

This issue was extremely debated by the behavioural literature also. Paul Slovic, an expert in human decision making and risk perception, draws a sharp dichotomy between the two risk assessments, i.e. subjective and objective. According to Slovic (1997), "… the public has a broad conception of the risk, qualitative and complex, that incorporates considerations such as uncertainty,

dread, catastrophic potential, controllability, equity, risk to future generations and so forth, into the risk equations". Indeed, psychological research on risk perception is being dominated by the psychometric paradigm, which was fruitful in revealing, through an empirical approach, some of the risk dimensions mostly influencing risk perception, among these dread and novelty of risk, mostly correlated to some specific risks such as nuclear power (Starr, 1969; Fischhoff *et al.*, 1978; Slovic, 1992; Sjoberg, 2000, Sjoberg *et al*., 2004). This research branch was particularly useful for improving the general understanding on how common people emotionally react, perceive risks and finally formulate their own rankings about hazardousness of different risk types, which in turn determine their further actions. In this process, emotions seem to be an important orienting mechanism, driven by a subtle type of emotion called affect, defined as a positive (I like) or negative (I dislike) evaluative judgment towards a stimulus (Slovic, 1999, Slovic *et al*., 2002). For this reason, Slovic (1999) puts himself in contrast with policies just relying on objective evaluation, affirming that also the process according to which people subjectively elaborate risk should have its own weight in risk management regulatory processes.

On the contrary, Cass Sunstein, an American legal scholar who supported the White House Office of Information and Regulatory Affairs during the Obama administration, strongly affirms that risk management and regulatory process aimed at risk reduction should be based on rational evaluations, because "While experts opinion rely on cost-benefit analyses, individuals believes are strongly biased by emotions about risks, being their attention caught by worst-case scenario, commonly emphasised by cascade or polarising effects, with devastating impacts on regulatory process, being these pushed to endorse the precautionary principle" (Sunstein, 2003). However, coherently with Kahneman's (2012) view, it can be inferred that the two positions are the two sides of the same coin, that means that psychology should effectively contribute to underpin risk management policies by connecting the scientific skills of the expert community, with behavioural attitudes and emotions of common citizens.

3. Seismic risk and prevention policies: an overview on Italy

Earthquake is one of the natural calamities featured by the highest destructive and deadly potential, very often associated with a massive loss in terms of casualties, as well as with a severe socio-economic impact. Compared with other natural risks, such as floods, its occurrence probability, at least for major destructive events, is largely smaller. Generally speaking, the so called maximum considered earthquake, or maximum considered event (MCE), hence associable to an extreme event in terms of potential losses, is an earthquake that is expected to occur for a specific area or region, once in approximately 2,500 years, with a resulting 2% probability of being exceeded in 50 years. In terms of annual frequencies, major and destructive events are characterised by very small likelihood (to make an example, 0.0004 corresponds to the annual probability of an event happening once in 2,500 years), while less severe quakes are usually being associated with higher annual frequencies, though still smaller than 0.1 (Meletti and Montaldo, 2007).

Italy is one of the countries of the European continent characterised by higher seismic risk, due to both its high seismic hazard (i.e. frequency and severity of earthquakes) and its very high territorial vulnerability (because of the fragility of the building stock, of the infrastructural, industrial, production and service assets as well as of its built cultural heritage) and a very high exposure (due

to population density and the incommensurable value of its historical, artistic and monumental heritage). Hazard maps provided by the National Institute of Geophysics and Volcanology (INGV) show that the highest seismicity is mostly concentrated along the Apennines ridge, south-eastern Sicily and north-eastern Friuli, with quite sensible variations overall the country and among different regions. The first rational seismic hazard of the country was made official between 1981 and 1984, when the territory was divided in to three homogeneous zones with decreasing hazard. This classification was used as reference for the application of seismic codes. Each zone was defined on the basis of the occurrence frequency of earthquakes of given intensity. This early zonation classified a total of 2,965 municipalities in seismic zones out of 8.102, amounting to just 42% of the entire building stock of the country. Only in 2003 the last seismic classification of the country was extended to the whole country, issuing four different zones with decreasing hazard from Zone 1 to Zone 4. Today around 9% of Italian municipalities is located in Zone 1, 28% in Zone 2, 19% in Zone 3, while the remaining percentage (44%) is associated to a very low hazard level (Zone 4). The above overview implicitly outlines quite a puzzling situation: buildings realised before the seismic classification did not have to comply with any seismic code and hence these buildings are featured by very high seismic vulnerability (Di Pasquale and Orsini, 1997; Dolce *et al.*, 2000). Moreover, since most of the constructions were realised before municipality seismic classifications, including modern buildings of last century, seismic vulnerability is the biggest concern in seismic prevention policies. In addition, illegal buildings or modifications of existing buildings, mostly realised during the 1960s and 1970s, are very common in some regions of the country, including the most seismic prone areas. Recent data provided by the Italian Data Census Institution (ISTAT) highlight that, notwithstanding the downfall of around 60% of the building industry after 2008, unregulated construction activity was less subjected to decrease (ISTAT, 2015).

In terms of expected impact, Italian risk maps developed by Civil Protection Department in 2001 (Lucantoni *et al.*, 2001), as well as subsequent similar studies, highlight major losses (in terms of casualties, damage to building stocks, and direct and indirect economic losses) mostly concentrated along the Apennine ridge, the NE side of the country and the SE of Sicily, coherently with the Italian hazard map (Fig. 1).

There is no doubt that seismic risk prevention represents an important priority in the Italian public policies. Moreover, among the three parameters governing the risk formulation (hazards, exposure, vulnerability), vulnerability and exposure are the ones directly affected by human activity and hence the ones upon which prevention policies can effectively rely for seismic risk mitigation.

The severe losses occurred in the most recent seismic events in the country (24 August 2016: 299 victims, 6 April 2009: 308 victims, 20 and 29 May 2012: 27 victims) provide tangible proofs of how preventive measures can hinder further damage to occur in case of future seismic shocks. Some evidences are dramatically still visible: when comparing two little towns stricken by the same recent 2016 quake, Amatrice (Rieti province) and Norcia (Perugia province), the difference in terms of losses in residential buildings is impressive. The former was completely destroyed by the earthquake, with largest rate in terms of casualties and economic impact whose total amount is currently being finalised. The second, seismically retrofitted after the 1979 Valnerina earthquake, survived to the most recent event, just reporting sensibly smaller economical losses and, above all, no victims. This testifies that prevention goals, such as human life safeguard, were fully achieved.

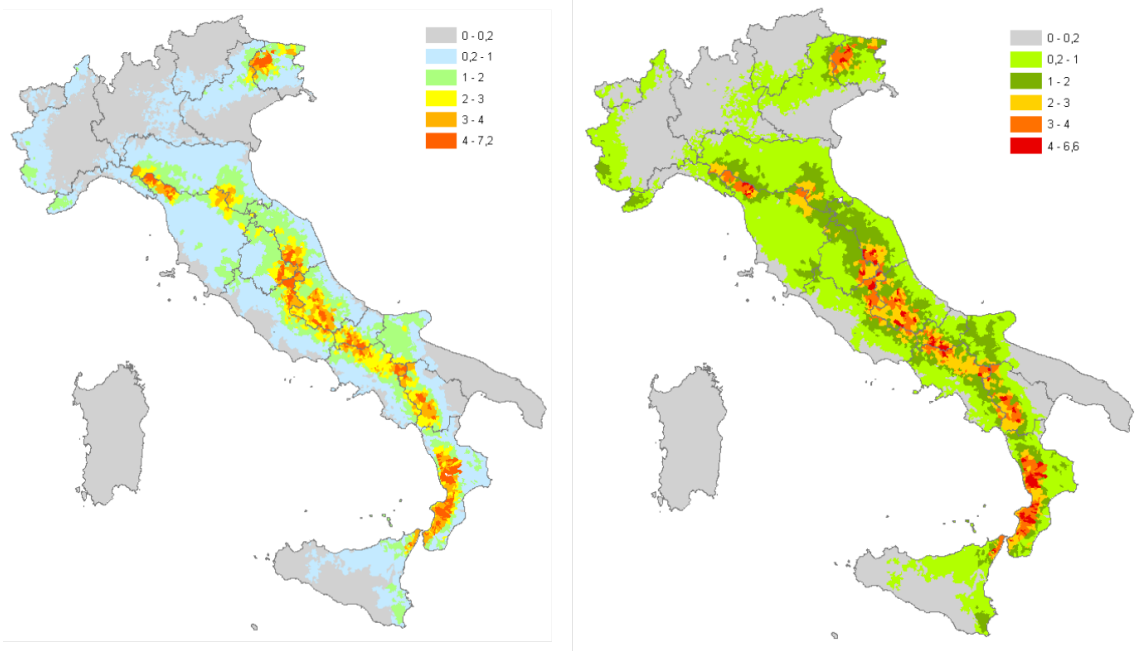

Fig. 1 - Italian seismic risk maps relevant to a period of 100 years: left: collapsed buildings per municipality; right: population potentially involved in collapses per municipality (Lucantoni *et al.*, 2001).

According to the new code of Civil Protection (2 January 2018), prevention activities in Italy are under the coordination of the Civil Protection Department, together with other tasks related to the risk management cycle (prediction and warning, mitigation, emergency management and emergency overcoming). The Department addresses, promotes and coordinates, in strict cooperation with regional and local public administrations, and further components of the system, all activities related to risk management, whose implementation is being issued at local level.

Over the last 15 years the Italian Government, through the Italian Civil Protection Department, has strongly emphasised the need of supporting seismic prevention by financing, coordinating and monitoring at central level a wide range of initiatives, including structural prevention aimed at seismic upgrading of buildings, whose local implementation is carried out at regional and municipal level.

Since 2003 the Italian Government has been funding some prevention programs aimed at seismic upgrading public buildings, relying on economic incentives to public administrations. More recently, following the 6 April 2009, Abruzzo earthquake, a further funding program of about one billion euros in seven years, though "the allocated amount is just a small fraction of what is really needed to solve the problem in Italy and less than one half of the expected average annual cost due to earthquakes" (Dolce, 2012).

According to a perfectly rational decision-making behaviour, previously evoked by Jackson (1981), all the actors involved at different territorial administrative levels (Regions, municipalities, citizens), should perform coherently with the risk level associated to their respective territories. The regions are expected to decide, within their territorial competence, which are those municipalities characterised by the highest risk levels on which to allocate the available economic resources.

Municipalities, in turn, should supervise prevention works so that they are scheduled and completed timely. Households, should wisely use incentives to promptly retrofit their properties and increase their protection measures against earthquakes. The administrative chain should work through an effective communication process by transferring all the information and knowledge needed along the actors of the institutional chain.

As outlined by Mauro Dolce, who coordinates the technical activities of the Italian National Seismic Prevention Program, this task is rather difficult, as a matter of fact "in spite of the enormous expected loss, seismic prevention remains a difficult objective to fully achieve, due to the high costs implied, the long time needed to achieve objectives, the little sensitivity of the public opinion and, consequently, the scarce interest in the political leadership" (Dolce, 2012).

The program, nearly over at the time this paper was written, showed several delays and controversial behaviours by all the actors involved, from public administrations committed at different territorial levels to citizens who are the final recipients of the preventive measures. Moreover, these behaviours seem uncorrelated with the level of territorial seismic risk.

Public administrations (i.e. the prevention managers at the local level) are late in spending the public funding and in scheduling prevention works, as well as in completing structural reinforcements timely. On the other hand, households often crowd out or do not timely complete the protective measures they were funded for.

It is worth noticing that other measures undertaken, particularly in recent years by the Italian Government (more specifically the Ministry of Transportation and Infrastructure), rely on de-taxation process. This mechanism, undertaken since 2013 with weaker measures (Law 90 of 2013) and modest results, was considerably strengthened by the 2017 Government Budget Law, though feedbacks on recent outcomes are still premature for the time being.

Very low seismic awareness can be also observed in non-structural prevention activities, such as emergency urban planning who are in charge to single municipalities. Recent data collected by the Civil Protection Department highlight that 85% of the municipalities have a contingency plan, while the remaining percentage (15%) is still pending. These data are particularly significant when referred to territorial areas having experienced, in the past, severe seismic events, like southern municipalities stricken by 1908 quake.

The reasons of this incoherent behaviour and uneven response in prevention activity over the Italian territory are difficult to identify and certainly rely on several factors, including political pooling, cultural and economic factors. Though, some explanations can be provided by behavioural science. In the following, the most important behavioural mechanisms, cognitive biases and risk misperception which can hinder individuals and decision makers from undertaking seismic risk reduction measures are investigated and discussed.

4. Citizens and public administrations: two different perspectives

Simplifying the decision making space, two main actors can be identified in the prevention cycle who are responsible for protective measures against earthquakes: the public administration and the citizens. Of course, reality is much more complex (Dolce and Di Bucci, 2014, 2015), but we decided to overlook the behaviour of decision makers, such as politicians, scientific community and stakeholders, and to focus on these two actors. Public administration is responsible for the

civil community and must make decisions on its behalf. Citizens are responsible for themselves being at the same time the final recipients of the public administrator's decisions.

Citizens and public administrations are different decision-making actors, at least with respect to two aspects. The first is that citizens decide for themselves, while administrations decide for others. The second is that citizens decide in small family contexts, while administrations decide in groups usually after a long negotiation process.

The first of these issues, i.e. the 'self-other' perspective, could imply different decision-making processes. According to Viale (2009), public administrations are affected by the "agency effect" according to which they must make decisions on behalf of a community. The central fact is that utility flows from the decision maker (or public manager) outwards, since the cost-benefit trade-off of his own decisions will impact on the community and not on himself (Viale, 2009). This aspect can lead to specific consequences. Since the decision involves a certain degree of risk, risk taking for the self can be different from risk taking for others. In this respect, it has been noticed, for example, that participants in a study were more likely to encourage risk-taking behaviour when making decisions or giving advice on behalf of a friend than they were when deciding for themselves (Beisswanger *et al.*, 2003). Moreover, compared to when participants had to decide for themselves, when they had to decide for others they were less risk averse (i.e. more risk seeking) in front of a possible gain but also less risk seeking when they were confronted with decisions involving a possible loss, thus showing a reduced framing effect in decision making under risk (Zhang *et al.*, 2017). Likewise, it has been found that the natural loss aversion (i.e. losses looms larger than gains) is significantly lessened among people choosing for others even when real money is at stake (Polman, 2012). This general "dulling effect" (i.e. reduced decisional biases but also reduced protective behaviour) that characterises decisions making for others, could explain why some public administrations do not show so much proactive behaviour in adopting seismic prevention measures for their community or do not promptly comply with prevention regulatory process. Under this point of view, being the risk transferred to other individuals, who are seen as externalities, their concern could be considerably lessened than in the case of being personally exposed to the same risk.

On the other hand, it must be considered that the roles taken by decision makers imply an accountability to perform certain functions associated with those roles. Responsibility can also include moral obligations that are usually related to the functional obligations of the role. In this sense, accountability of decision makers, i.e. the readiness or preparedness to give an explanation or justification to relevant others (stakeholders) for one's judgments, intentions, acts, and omissions (Bivins, 2006), could be a relevant cue positively influencing the final decision of public administrator. To make a practical example, the lack of specific actions like retrofitting a vulnerable hospital could become very harmful for the decision maker if, in case of earthquake, the damage suffered by the building caused dysfunction to the health service, even in the emergency phase. Conversely, decision maker would be positively accounted when preventive interventions were able to avoid damage or insurance was timely purchased. This was the case, for instance, of all public buildings of a little town of central Italy stricken by the 2016 earthquake sequence, that had all been previously insured by the municipal administration (www.ansa.it/marche/notizie/2017/10/16/5-mln-a-comune-ascoli-assicurato-sisma_08e7b313-4151-4617-ab96-cce96ec76add.html).

Finally, it is worth noticing that public administrations, as being realised by multiple subjects

each other interacting on an organised context, can be affected by all biases typical of group decision-making. Groups tend to be more accurate, faster and more productive decision makers than individuals, but they are less efficient (they perform below their best member). Moreover, groups are subject to lack of motivation (social loafing), they tend to conform to the majority attitude, they are subject to group-think (the suppression of dissent and the exaggerated impression of group invulnerability), and group polarisation (they endorse more extreme decisions following discussion).

Furthermore, the same biases that affect individuals can also affect decision-making groups, such as belief perseverance (a group utilises information in their decision-making that has already been deemed inaccurate), sunk cost fallacy (a group remains committed to a given plan primarily due to the investment already made in that plan, regardless of how inefficient and/or ineffective it may have become) and hindsight bias [group members falsely overestimate the accuracy of and/or the relevance of their past knowledge of a given outcome: Forsyth (2006)].

These biases can strongly threaten the implementation of prevention policies and protective measures against earthquakes, by excessive simplification of more complex phenomena (Meyer and Kunreunther, 2017), by overlooking the chance of high-consequence low-probability events while rather investing or re-investing on useless programs, disregarding *de facto* the safety of their community.

5. Intertemporal choices on prevention activities

It commonly happens that individuals invest on daily life activities or goods in order to satisfy their urgent and pushing needs characterised by little temporal span. They spend, often squandering, their money to refurbish their kitchen, while, on the other hand, they overlook to invest in their own safety disregarding to protect themselves and their homes from the occurrence of rare events, such as earthquakes. Although this choice is certainly biased by social demand and social accountability needs, on the other hand it is ascribable to a cognitive difficulty in processing cost-benefit analysis of seismic prevention activities. These could explain also why, in Italy and elsewhere in the world, seismic prevention is barely afforded, even in the presence of financial incentives, while very seldom it is realised by individuals at their own expenses.

Public administrators are similarly struggled by this controversial perspective when dealing with prevention activities. As a matter of fact, the temporal span covered by their public appointment or mandate is much shorter than long-term benefits coming out by mitigation policies. This explains why they prefer to invest on issues raising their short-term public accountability than on the long-term safety of the population they are responsible for. Also, people tend to be more prudent and risk averse in the present, while accepting more risk when their decision is resolved in the future (Savadori and Mittone, 2015), suggesting that when the public administrator is confronted with a choice to take now, but that will have its consequences in the future, she/he will show a greater tendency to be excessively risky in the present decision, reducing the planning of prevention activities. According to the original thought of Fisher (1930), the incapacity to process future outcomes brings about individual impatience. This depends on four main characteristics of his income stream: the size, the time shape, the composition, and risk. One can note that this latter cue particularly fits with prevention activities, being these highly affected by the unpredictability

of seismic occurrence. This incapacity, which Meyer and Kunreuther (2017) define as "myopia bias", extensively investigated by neurologists and economists, is characterised by the tendency to focus on the short-term rather than on long-term consequences of an actions, because of the intrinsic difficulty of our mind in representing a distant-in time consequence. The problem implies intertemporal choices, according to which people evaluate the pleasures and pains resulting from a decision exponentially discounting the value of outcomes according to how delayed they are in time. Discounted utility provides a solid ground to explain how people actually make intertemporal choices for daily life as well as how policy decisions can be much affected by hyperbolic discounting (Lowenstein and Thaler, 1989; Berns *et al.*, 2007).

According to the above, seismic prevention activities are subjected to two distinct anomalies, heavily affecting the decision making. First, is the fact that potential benefits resulting from undertaking proactive behaviour are largely delayed compared to the costs of a seismic retrofitting or upgrading. The span of the delay is comparable to the earthquake occurrence, and hence long-term shifted away. Second, the benefits are nor tangible and neither easily quantifiable, being these associable to disasters that, because of the prevention actions, did not happen at all (Annan, 2002).

This intertemporal construal also helps to understand a typical behaviour, such as the tendency to procrastinate, being this ascribable to the typical attitude of individuals to turn down to spend money for protection today, but see it as a wise investment for tomorrow (Meyer and Kunreuther, 2017).

6. Planning fallacy and unrealistic optimism

Seismic risk reduction strategies, especially those supported by economic incentives, are scheduled by specific actions that both public institutions and citizens, being the potential beneficiaries of preventive measures, should timely attend. What often happens is that, after the first actions accomplishing the prevention tasks, they slow down or completely stop their planning of future proactive actions. To make an example, Regional administrations are found much more compliant at the beginning of the seismic prevention programs, rather than in its further development. New prevention tasks are often enthusiastically undertaken, though after a while they fall short.

This behaviour can be explained by specific biases. Generally speaking, in response to uncertain and risky situations, humans have a tendency to simplify their decision making problem. Individuals responding to a threat, are likely to rely on just one early action, even when it provides only slight incremental protection or risk reduction and may not be the most effective option. Once the first proactive measure has been already prompted, decision makers often take no further action, presumably because the first one succeeded in reducing their feeling of worry or vulnerability. This phenomenon is called the "single action bias" (Weber, 1997). Not only decision makers, but also individuals can be subjected to this bias: they may be worried about preparing in advance their first aid kit and emergency reference material (as recommended by some earthquake safety checklists provided in several countries), but they miss some other important easy home-preparedness measures, like anchoring to the wall the tall and heavy furniture that could topple, with very harmful consequences when earthquakes occur [see among the others FEMA (2017)].

One further bias increasing this reduction of prevention awareness is unrealistic optimism (Weinstein, 1980). The implicit thought is that harm is something that will happen to other people or, in other words, they think they are at a lesser risk of experiencing a negative event compared to others (Jolls, 1998; Shepperd *et al*., 2002; Sharot, 2011).

According to Meyer and Kunreuther (2017) optimistic bias is further incremented by two reasoning procedures. One is the above mentioned "availability heuristics" according to which "instances in which one did not experience harm will come to mind much more readily than those in which one did". The other one is that decision makers and individuals build up their own scenario on what they hope will come, and not on statistics or probabilities provided for the specific case. This attitude brings about detrimental consequences on the capability and willingness either of decision makers or individuals to plan future actions and achieve final goals, revealing a further bias known as "planning fallacy" (Kahneman and Tversky, 1979; Kahneman, 2012). As a consequence of this psychological mechanism, predictions about how much time will be needed to complete a future task are too optimistic since decision makers hugely underestimate the time really needed. This usually happens regardless of the individual's knowledge of past tasks of a similar nature (Buehler *et al.*, 1994). A specific enforcement to reduce the planning fallacy and achieve the final goals of prevention policies designed at central or national level is to schedule activities according to a progressive implementation intention plan (Koole and Spijker, 2000).

7. Prevention versus insurance

In recent decades, prevention and insurance policies, have been much discussed both with regard to different kinds of market insurance and, although primarily within a European context and in relation to an ongoing discussion about the need for a shift towards an "active" welfare state, with regard to social insurance (Dubois, 2011).

In Italy, differently from other countries such as the United States, the insurance market against natural disasters like earthquakes, is not so widespread, apart from specific private sectors like commercial or industrial assets. As previously outlined, the policy prompted by the Italian government, over the last years, was a preventive one, requiring households or institutions to undertake specific measures for reducing or eliminating future potential losses including human life, before the occurrence of the hazardous events (Dolce, 2009, 2012). At the same time, losses caused by earthquakes occurred over the last 50 years have been, so far, entirely sustained by the government, with a global expenditure for recovery and reconstruction exceeding 150 billion of euros, in 2012 (Dolce, 2012).

Some considerations can be made about potential differences between these two protective measures, with the final purpose of understating if different behavioural mechanisms can characterise each one.

Insurance and prevention are two social responses to risks. Generally speaking, insurance is a mean of protection from financial or economic losses, relying on a risk-transfer mechanism. It is a form of risk management primarily used to hedge against the risk of contingent, uncertain losses. It involves pooling funds from insured entities (known as exposures) to pay for the losses that some may incur [see among others Vaughan and Vaughan (2013)].

On the other hand, prevention expresses the concept and intention to control the loss (loss reduction). Strengthening a building to make it earthquake-resistant is an example of loss reduction, since it does not reduce the probability of an earthquake occurring, which cannot be modified, but it reduces the amount of expected losses.

The two mechanisms seem to be driven by different motivation behaviours. Prevention is driven by incentives to avoid or reduce damages, including human life losses, prior to the occurrence of the hazardous event. It is a costly activity implying that properties subjected to prevention (such as houses, public buildings, and so on) will have to remain undamaged or slightly damaged (more precisely, however, they are expected to be damaged coherently with the limit states they have been designed to resist). On the other hand, insurance requires a fee, much less expensive than prevention costs, paid from insured entities, dependent upon the frequency and severity of the event occurring. Hence, prevention is costly at the present and the benefits are possibly obtained far in the future. As for all future-resolved decisions, the decision to prevent will be very likely subject to procrastination, mainly because the benefits are psychologically distant. On the other hand, insurance could lessen incentives to take preventive measures, leading to behaviours such as "moral hazard" defined by "any situation in which one person makes the decision about how much risk to take, while someone else bears the cost if things go badly" (Krugman, 2009; Dubois, 2011).

From a behavioural point of view, the attitudes of individuals and public administrations towards these two mechanisms are still unsolved. According to the classic economic model, the two mechanisms are substitutes, which means that the two terms are alternative to each other: the choice for self-protection is alternative to the choice of self-insurance (Ehrlich and Becker, 1972).

However, analysing the specific case in which a citizen has to decide upon the house of property, the two actions seem to be complements. In the case of insurance the citizen will act to reduce the economic damage due to a natural disaster. In the case of prevention, he will act to reduce the probability that the same natural disaster will cause a damage, including loss of life, as well as some indirect losses and uncomfortable conditions, like the temporary relocation consequent to un-usability of the house of property. The probability of a natural disaster occurring is always the same, but the framing is different. In the "prevention" frame the citizen increases resilience (making his house and himself less subject to losses), while in the "insurance" frame the citizen has to rebuild or to repair the house to regain the same economic value that it had before. Endowment effect and loss aversion might act as determinant features in this comparison. They would predict, in principle, that the motivation to prevent should be stronger than the motivation to insure. Loss aversion and the endowment effect (Kahneman *et al.*, 1990; Thaler *et al.*, 1991) predict that owning a good increases the value of the good because the loss of that good weights more than the gain of the same good. Hence, when an individual already owns a good (e.g. a property house), the motivation to avoid loosing that good (as well as the money asked to sell it) is greater than the motivation to obtain that good if she/he did not owned it before. If loss aversion is a key factor acting in the choice between insurance and prevention, then we should also observe that the more time one owned a good the more loss averse one should be. Also, the greater the value of the good the more loss averse one should be. Always following this principle, public administrators who share a cultural history with the place (e.g. who were born in the place that they administer) should have more aversion to losses and more endowment effect, therefore take more action than administrators who do not feel culturally belonging to the place they administer.

When comparing the two systems with respect to earthquake protective measures, moral hazard could be one important bias hindering effectiveness of insurance system. On the other hand, unrealistic optimism, underestimating the likelihood of losses including human life, could work as a main deterrent of prevention measures, strongly amplified by the above mentioned intertemporal struggle between short term-costs and long-term benefits. In fact, having a property for many years and, at the same time, never experiencing a seismic event during these years, reinforces inevitably, in the minds of people, the idea that the event should be ignored, i.e. a belief that it will never happen. In fact, it has been experimentally demonstrated that the experience with a rare event, due to its rarity, causes individuals to underweight its probability (Hertwig *et al.*, 2004).

One further hypothesis, applicable to the Italian context, is if the refund issued by government, following major disasters, can trigger mechanisms such as the above mentioned moral hazards. In this case, this bias could be mitigated by pushing individuals and public administrations to more effective commitment in taking on their own responsibilities with respect to the implementation of preventive measures.

8. Social dilemmas and social norms

Selfish behaviour of individuals can commonly trigger social response known as "social dilemmas": situations according to which the selfish situation in which an individual profits from selfishness unless everyone chooses the selfish alternative, in which case the whole group loses (Allison *et al.*, 1996). Problems arise when too many group members choose to pursue individual profit and immediate satisfaction rather than behave in the group best long-term interests. Social dilemmas can take many forms and can explain several behaviours such as crowding out from proactive behaviour against earthquake protection. Individuals may think that they can benefit from other's proactive and costly measures, without any individual and personal effort being spent, according to the well-known "public good dilemma" (Brechner, 1977). Usually this unconditional expectation is being claimed to public administrations. Public intervention and economical support is considered always due, without specific personal commitments and individual responsibilities.

This mechanism implicitly can lead to other social dilemmas, which can also trigger when protection from natural disaster is involved. To make an example, the common good which can also be seen as the natural and built environment has been devastated and exploited over the years with every kind of abuse, revealing an underlying incapability of individuals to share common good, according to the well-known "Tragedy of the Commons" (Hardin, 1968).

Social norms provide collective solutions to mixed-motive games or social dilemmas, in order to solve conflict of interest and also offer solutions for join gain, by transforming these games into coordination games. "This transformation, however, hinges on each individual expecting enough other people to follow the norm too. If this expectation is violated an individual will revert to playing the original game and to behave selfishly" (Bicchieri, 2006).

However, the dynamics of social norms formation show that this transformation process can often turn into poor equilibrium and consequent social norms, when these are relying on bad conventions. This in turns determines justification of detrimental behaviour and its transformation

into bad social expectations, based on pluralistic ignorance (Bicchieri, 2006). Again, this is what happened to abusive constructions which were embedded into social norms of some areas of Italy. The modification of this wrong behaviour, which actually hinders implementation of prevention measures is not an easy task, since these norms threaten implementation of formal norms issued by the government. Their prior modification into proactive social norms would be, then, required in order to enforce the regulatory process and empower prevention policies (Bicchieri, 2006; Sunstein, 2013).

9. Experience and learning process

Like many other natural calamities, earthquakes are characterised by their repeated occurrence over the time. According to the different hazards of the territory, they can be more likely to occur with low consequences and conversely; we cannot predict exactly when they will happen again, but we can averagely estimate their likelihood across the territory.

It is thanks to this repeated experience that several lessons from the past centuries have been learned, also by a process of trial and errors. A vivid example is provided by anti-seismic constructive techniques that greatly improved in regions or localities stricken by severe events, in order to make buildings more resistant to this insidious and unpredictable calamity.

This "learning" process brought about the growth of different local anti-seismic craftsmanship all over Italy, even before the issue of specific standard codes. Italian history is full of similar examples who contributed, across the time, to build up anti-seismic constructive techniques, according to the principle "build back better". However, this learning process does not remain stable and constant over time.

A typical example is provided by what happened in Calabria and Sicily after dreadful earthquakes occurred in 1783. Following that experience, a new constructive system was specifically issued in order to lessen future damage and to save lives. This system, called "la casa baraccata", was characterised by severe height limitations, foundations, and special "X" timber bracing to contrast lateral forces, such as those activated by earthquakes (Tobriner, 1983). However, the following major earthquake in the same regions, in 1908, found these territories still unprepared, since many prescriptions of the Bourbon construction code had been unattended after some decades (Barbisan, 1997; Valtieri, 2008).

Most of Italian building heritage provides a vivid evidence of the amnesia bias according to which "our memories for pain tend to be short-lived, particularly when they can be replaced by something more positive" (Meyer and Kunreuther, 2017). This means that direct experience seems to be an important emotional driver to raise individual's awareness, though its beneficial effects tend to lessen over the time to be overwhelmed by other external positive stimulus. This mechanism can be seen as an application of the mentioned availability heuristic, according to which people tend to heavily weigh their judgments toward more recent information, making new opinions biased toward latest news (Tversky and Kahneman, 1974). Past experience is also biased by the "pick-end rule", according to which an event (mostly negative) is not judged by the entirety of an experience, but by prototypical moments (picks) as a result of the representativeness heuristic. The remembered value of how they felt at its peak dominates the actual value of an experience, regardless of its duration (Kahneman, 2012).

The lessening of protective measures over the time from a previous past experience is also ascribable to a further factor named by Meyer and Kunreuther (2017) the "Fear of Crying Wolf", revealing the frustration of individuals due to the fact that costly proactive actions, when carried out, get unrewarded, since the efforts made for protective measures are perceived as useless until the disaster occurs. However, according to recent experimental work on risky choices (Hertwig *et al.*, 2004) underestimation of risk in case of rare events can be compensated by effective description, which tends to overweight the probability of rare events, coherently with the possibility effect (i.e. overweighting of low probabilities).

Hence, far past experience and lack of positive reinforcements can become very harmful drivers for self and other protections against earthquakes, but effective communication can be a useful driver for compensating memory fading (Lotto *et al.*, 2005; Savadori and Rumiati, 2005; Savadori, 2007).

10. Concluding remarks

Seismic risk and related self-protection measures have been analysed under the lens of behavioural economics, showing how cognitive human mechanisms might affect the decision-making process under risk and uncertainty. This research branch provides a wide range of psychological mechanisms, cognitive biases and risk misperceptions which can trigger crowding out either of individuals or decision makers from undertaking seismic risk reduction measures. The major reasons that can trigger underestimation of seismic risk and consequent crowding out from seismic protection measures have been dealt with. Taking advantage by the specific experience of some of the authors in the field of seismic mitigation policies at institutional level, the Italian context was used as a benchmark, by outlining some criticalities encountered during the implementation of these measures.

First, a different perspective in processing decision making in seismic risk management can be associated to two actors: the individual and the public administrators. Risk taking for the self can be different from risk taking for the other, so that decision makers could be pushed to underestimate the risk posed on civil community. Besides, the decisional process of a public administration implies group decision making, potentially affected by several biases (e.g. group polarisation, belief perseverance, sunk cost bias, hindsight bias). On the other hand, the roles taken by policy makers imply an accountability towards other who judges their performance. In the authors' view, increasing the impact on policy makers accountability could be an effective driver for more responsible decision making in seismic risk prevention.

A second psychological mechanism affecting public administrators and individuals when dealing with seismic prevention activities can be ascribed to the problem of intertemporal choices, implying a tendency to focus on the short-term rather than on long-term implications of actions, because of the difficulties of our mind in representing long-term consequences. A possible solution to this controversial mechanism is the introduction of short term rewards, re-balancing the implicit cost-benefit analysis over all the entire process. Rewards should not only be economical incentives, but should also be aimed to underpin intrinsic motivation to proactive behaviour, such as staking on self-accountability.

A further mechanism encountered during the implementation of activities related to seismic risk is the planning fallacy, which determines the incapacity to complete timely some scheduled actions. This incapability can be ascribed to different bias, among which, the single action bias and the unrealistic optimism. As a consequence, predictions about how much time will be needed to complete a future task are too optimistic since decision makers can hugely underestimate the time really needed. Among the specific means to reduce planning fallacy there is the scheduling of activities according to a progressive implementation intention, by implementing further actions according to shorter intervals.

One more aspect which has been discussed is related to the psychological mechanisms which can trigger in relation to two different protective measures: prevention and insurance. Preventive actions might be influenced by the endowment effect and loss aversion. The endowment effect assumes that the possession of an asset increases its value. So the potential loss of the good should be experienced as more painful (more loss aversion) when it is owned. This implies that longer-term homeowners will be more interested in protecting their home than those who have been owners for less time or who have just inherited the building.

Furthermore, prevention is also susceptible to the unrealistic optimism that goes in the same direction as the underweighting of rare events producing an illusory idea that "it will never happen to me", reducing the perceived likelihood of the risk of losing life or being injured due to an earthquake. The loss of life is not safeguarded by insurance policies, being this transformed into monetary losses. On the other hand, risk-transfer mechanisms, such as insurance, may be more likely affected by moral hazard. However, the relation between the two measures, under a behavioural point of view, is still largely unsolved and experimental work would be beneficial to this issue. This would help to empower or correct actual policies carried out by governments, or even to accomplish possible interaction of the two systems.

One further aspect strongly influencing proactive measures is represented by social norms which can be seen as collective response to solve social dilemmas, such as "public good dilemma" (according to which individuals take advantage from other's proactive and costly attitudes without any personal effort) or the "tragedy of commons" (revealing an underlying incapability of individuals to share common goods). Modification of poor social norms, based on pluralistic ignorance, or creation of new beneficial social norms, can be both mechanisms for empowering the regulatory process and creating a phenomenon of compliance without enforcement. Under this point of view communication and training on seismic-related topics are two important tasks.

Last, but not least, it is worth mentioning the incapacity, of both individuals and policy makers, to keep over the time vivid memories of past, even severe, seismic events. In other terms, whilst it is fully recognised that past direct experience is one important emotional driver to raise individual's awareness, on the other hand its beneficial effects tend to lessen over the time to be overwhelmed by other external positive stimulus. This mechanism can be seen as an application of the "availability heuristic". By applying this concept to the different seismic history characterising each geographical region worldwide, it could be inferred that low-probability high-impact seismic history could be much more detrimental for collective memory, compared to high-probability and low-impact seismicity. This consideration, if also experimentally confirmed, could lead to conclude that different tools for raising community awareness should be defined in order to keep the "learning" process vivid across the time. Effective and differentiated communication, according to the recipient needs, could be a powerful tool to this goal. In other words, instead of

increasing the fear of earthquake, it would be useful to communicate to the citizen-decision maker what advantages it is possible to obtain by doing certain actions, thus increasing the sense of self-efficacy in controlling and determining the future. Recognising the risk is important, but with this awareness, the citizen should be helped to autonomously guide a productive transformation toward a better future. To increase the motivation to explore new forms of protection / prevention, and therefore be able to remove the citizen from the condition of decisional inertia and *status quo* bias in which we all are embedded. The simple dissemination of small interventions, not too expensive, in the direction of prevention (e.g. even just sign to receive more information from the municipality on the degree of building resistance of the home) could be beneficial to this purpose.

To sum up, the question of how people and decision makers deal with seismic risk, deciding or not deciding to undertake protective measures for themselves and for the people they are responsible, is a very complex and subtle task. This also means that the psychological mechanisms discussed in this paper can trigger individually or mutually combined, according to specific cases and contexts. In other terms, every situation needs to be analysed in detail in order to make predictions on behaviours more reliable and to find out, in the end, specific de-biasing tools for enforcing prevention strategies.

In the authors' opinion this research branch, effectively supported by experimental work, represents a fundamental step for empowering strategic policies and developing specific and tailored measure, among which effective communication for all actors involved in the process. In the Italian context, this need has recently become much more pushy due to the enforcement of the new Civil Protection Code (Decree Law n. 1 of 2 January 2018), according to which the civil community, and particularly citizens, are seen as main actors, and not as mere recipients, of the civil protection activities aimed at increasing resiliency of community (art. 31 of Decree Law).

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References

Allison S.T., Beggan J.K. and Midgley E.H.; 1996: *The quest for "similar instances" and "simultaneous possibilities": metaphors in social dilemma research*. J. Pers. Soc. Psychology, **71(3)**, 479-497.

Annan K.; 2002: *World summit on sustainable development*. Johannesburg, South Africa. <sustainabledevelopment.un.org/milesstones/wssd>.

Barbisan U.; 1997: *Il terremoto e le tecniche costruttive a Reggio Calabria e Messina nel 1908*. Costruire in Laterizio, **56**, 116-120.

Beisswanger A.H., Stone E.R., Hupp J.M. and Allgaier L.; 2003: *Risk taking in relationships: differences in deciding for oneself versus for a friend*. Basic Appl. Soc. Psychology, **25(2)**, 137-143, doi:10.1207/S15324834BASP2502.

Bernoulli D.; 1738: *Commentaries of the Imperial Academy of Science of Saint Petersburg*, translated by Sommer L. (1954) in: *Exposition of a New Theory on the Measurement of Risk*. Econometrica. The Econometric Society, 22(1), 22-36, doi:10.2307/190982.

Berns G.S., Laibson D. and Loewenstein G.; 2007: *Intertemporal choice toward an integrative framework*. Trends Cognit. Sci., **11**, 482-488, doi:10.1016/j.tics.2007.08.011.

Bicchieri C.; 2006: *The grammar of society: the nature and dynamics of social norms*. Cambridge University Press, New York, NY, USA, 278 pp.

Bivins T.H.; 2006: *Responsibility and accountability*. In: Fitzpatrick K. and Bronstein C. (eds), Ethics in Public Relations: Responsible Advocacy, SAGE Publications Inc., *Thousand Oaks, CA, USA,* Chapter 2, pp. 19-195, doi:10.4135/9781452204208.n2.

Brechner K.C.; 1977: *An experimental analysis of social traps*. J. Exp. Soc. Psychology, **13**, 552-564, doi:10.1016/0022-1031(77)90054-3.

Buehler R., Griffin D. and Ross M.; 1994: *Exploring the "Planning Fallacy"*: *why people underestimate their task completion times*. J. Pers. Soc. Psychology, **67**, 366-381.

Cardano G.; 1525: *Liber de Ludo Aleae (riedizione 2006)*. Tamborini M. (a cura di), Franco Angeli Edizioni, Milano, Italy, 240 pp.

Di Bucci D. and Savadori L.; 2017: *Defining the acceptable level of risk for civil protection 4 purposes: a behavioural perspective on the decision 5 process*. Nat. Hazard, **90**, 293-324, doi:10.1007/s11069-017-3046-5.

Di Pasquale G. and Orsini G.; 1997: *Proposta per la valutazione di scenari di danno conseguenti ad un evento sismico a partire dai dati Istat*. In: Atti 8th Convegno Nazionale L'ingegneria Sismica in Italia, Taormina, Italy, pp. 477-486.

Dolce M.; 2009: *Mitigation of seismic risk in Italy following the 2002 S. Giuliano Earthquake*. In: Tankut A.T. (ed), Earthquakes and Tsunamis, Geotechnical, Geological, and Earthquake Engineering, Springer, Dordrecht, The Netherlands, vol. 11, pp. 67-89, doi:10.1007/978-90-481-2399-5_6.

Dolce M.; 2012: *The Italian national seismic prevention program*. In: Proc. 15th World Conference on Earthquake Engineering, Lisboa, Portugal, 24 pp.

Dolce M. and Di Bucci D.; 2014: *Risk management: roles and responsibilities in the decision-making process*. In: Peppoloni S. and Wyss M. (eds), Geoethics: ethical challenges and case studies in Earth sciences, Elsevier, Amsterdam, The Netherlands, 450 pp., ISBN-10:0127999353, ISBN-13:978-0127999357.

Dolce M. and Di Bucci D.; 2015: *Civil protection achievements and critical issues in seismology and earthquake engineering research.* In: Ansal A. (ed), Perspectives on European Earthquake Engineering and Seismology, Springer, Cham, Switzerland, Geotechnical, Geological and Earthquake Engineering, vol. 39, pp. 21-58, doi:10.1007/978-3-319-16964-4_2.

Dolce M., Marino M., Masi A. and Vona M.; 2000: *Seismic vulnerability analysis and damage scenarios of Potenza town*. In: Proc. International Workshop on Seismic Risk and Earthquake Damage Scenarios of Potenza, Potenza, Italy, pp. 35-56.

Dubois M.; 2011: *Insurance and prevention: ethical aspects*. J. Primary Prev., **32**, 3-15, doi:10.1007/s10935-011-0234-z.

Ehrlich I. and Becker G.; 1972: *Market insurance, self-insurance, and self-protection*. J. Political Econ., **80**, 623-648.

Erto P., Giorgio M. and Iervolino I.; 2012: *Probabilità e rischio.* Ambiente, rischio, comunicazione - Decidere nell'incertezza, **4**, 64 pp.

European Commission; 2010: *Risk assessment and mapping guidelines for disaster management.* EU Commission Staff Working Paper, Luxembourg City, Luxembourg. <ec.europa.eu/echo/files/about/COMM_PDF_SEC_2010_1626_F_staff_working_document_en.pdf>.

FEMA (U.S. Federal Emergency Management Agency); 2017: *Earthquake safety checklist.* FEMA B-526, Washington, DC, USA, <www.fema.gov/media-library-data/1510153676317-82124ab3b0a31ea239f60acc8d46c2ba/FEMA_B-526_Earthquake_Safety_Checklist_110217_508.pdf>.

Fischhoff B., Slovic P., Lichtenstein S., Read S. and Combs B.; 1978: *How safe is enough? A psychometric study of attitudes towards technological risks and benefits*. Policy Sci., **9**, 127-152.

Fisher I.; 1930: *The theory of interest, as determined by impatience to spend income and opportunity to invest it*. The Macmillan Company, New York, NY, USA, 593 pp.

Forsyth D.R.; 2006: *Decision making*. In: Forsyth D.R., Group Dynamics (5th Ed.), Wadsworth Cengage Learning, Belmont, CA, USA, pp. 317-349.

Gigerenzer G.; 2002: *Calculated risks*: *how to know when numbers deceive you*. Simon & Schuster, New York, NY, USA, 320 pp.

Hardin G.; 1968*: The tragedy of the commons*. Sci., **162**, 1243-1248, doi:10.1126/science.162.1278 3859.1243.

Hertwig R., Barron G., Weber E.U. and Erev I.; 2004: *Decisions from experience and the effect of rare events in risky choice*. Am. Psychological Soc., **15**, 534-539.

ISO Guide 73; 2009: *Risk management - Vocabulary*, 15 pp. <www.iso.org/standard/44651.html>.

ISTAT; 2015: *Rapporto Bes 2015: paesaggio patrimonio culturale, il benessere equo e sostenibile in Italia.* ISTAT, **9**, 211-235. <www.istat.it/it/files/2015/12/09-Paesaggio-patrimonio-culturale-Bes2015.pdf>.

Jackson E.; 1981: *Response to earthquake hazard*. Environ. Behav., **13**, 387-416.

Jolls C.; 1998: *Behavioural economics analysis of redistributive legal rules*. Vanderbilt Law Rev., **51**, 1653-1677.

Kahneman D.; 2012: *Thinking fast and slow*. Macmillan, New York, NY, USA, 499 pp., ISBN 978-1-4299-6935-2.

Kahneman D. and Tversky A.; 1979: *Intuitive prediction: biases and corrective procedures*. TIMS Stud. Manage. Sci., **12**, 313-327.

Kahneman D., Slovic P. and Tversky A. (eds); 1982: *Judgement under uncertainty: heuristics and biases*. Cambridge University Press, Cambridge, UK and New York, NY, USA, 555 pp.

Kahneman D., Knetsch J.L. and Thaler R.H.; 1990: *Experimental tests of the endowment effect and the Coase theorem*. J. Political Econ., **98**, 1325-1348, doi:10.1086/261737.

Knight F.H.; 1921: *Risk, uncertainty and profit*. Houghton Mifflin Co., Boston, MA, USA, 682-690 pp.

Koole S. and Spijker M.; 2000: *Overcoming the planning fallacy through willpower: effects of implementation intentions on actual and predicted task-completion times*. Eur. J. Soc. Psychology, **30**, 873-888.

Krugman P.; 2009: *The return of depression economics and the crisis of 2008*. W.W. Norton & Company, New York, NY, USA, 191 pp., ISBN 978-0-393-07101-6.

Levin I.P., Schneider S.L. and Gaeth G.J.; 1998: *All frames are not created equal: a typology and critical analysis of framing effects*. Organiz. Behav. Hum. Decision Processes, **76**, 149-188.

Lotto L., Rumiati R. and Savadori L. (a cura di); 2005: *Rischi e comunicazione dei rischi*. Cleup, Padova, Italy, 190 pp.

Lowenstein G.F. and Thaler R.; 1989: *Anomalies intertemporal choice*. J. Econ. Persepctives, **3**, 181-193.

Lucantoni A., Bosi V., Bramerini F., De Marco R., Lo Presti T. and Naso G.; 2001*: Il rischio sismico in Italia*. Ingegneria Sismica, **1**, 5-35.

Meletti C. and Montaldo V.; 2007: *Stime di pericolosità sismica per diverse probabilità di superamento in 50 anni: valori di ag.,* Progetto DPC-INGV S1, Istituto Nazionale di Geofisica e Vulcanologia, Milano, Italy. <esse1.mi.ingv.it/data/D2.pdf>.

Meyer R. and Kunreuther H.; 2017: *The Ostrich Paradox*. Wharton Digital Press, Philadelphia, PA, USA, 132 pp.

Mill J.S.; 1904: *Principles of Political Economy: with some of their Applications to Social Philosopy*. D. Appleton, New York.

Polman E.; 2012: *Self-other decision making and loss aversion*. Organiz. Behav. Hum. Decision Processes, **119**, 141-150, doi:10.1016/j.obhdp.2012.06.005.

Samuelson W. and Zeckhauser R.; 1988: *Status quo bias in decision making*. J. Risk Uncertainty, **1**, 7-59, doi:10.1007/BF00055564.

Savadori L.; 2007: *Comunicare i rischi e i pericoli.* In: Rumiati R. and Lotto L. (a cura di), *Introduzione alla psicologia della comunicazione.* Il Mulino, Bologna, Italy, pp. 221-239.

Savadori L. and Rumiati R.; 2005: *Nuovi rischi, vecchie paure. La percezione del rischio nella società contemporanea*. Il Mulino, Bologna, Italy, 202 pp.

Savadori L. and Mittone L.; 2015: *Temporal distance reduces the attractiveness of p-bets compared to $-bets*. J. Econ. Psychology, **46**, 26-38, doi:10.1016/j.joep.2014.11.004.

Sharot T.; 2011: *The optimism bias: a tour of the irrationally positive brain*. Knopf Publishing, New York, NY, USA, 272 pp.

Shepperd J.A., Patrick C., Jodi G. and Meredith T.; 2002: *Exploring the causes of comparative optimism*. Psychologica Belg., **42**, 65-98.

Simon H.; 1957: *A behavioural model of rational choice*. In: Simon H.A. (ed), Models of man, social and rational: mathematical essays on rational human behaviour in a social setting, Wiley, New York, NY, USA, pp. 241-260.

Simon H. and Newell A.; 1972: *Human problem solving*. Prentice-Hall, Englewood Cliffs, NJ, USA, 934 pp.

Slovic P.; 1992: *Perception of risk: reflections on the psychometric paradigm*. In: Krimsky S. and Golding D. (eds), *Social Theories of Risk,* Praeger, New York, NY, USA, pp. 117-152.

Slovic P.; 1997: *Trust, emotions, sex, politics and science: surveying the risk assessment battlefield*. University of Chicago Legal Forum, **1**, 59-99.

Slovic P.; 1999: *Trust, emotions, sex, politics and science: surveying the risk-assessment*. Risk Anal., **19**, 689-701.

Slovic P., Finucane M., Peters E. and MacGregor D.G.; 2002: *The affect heuristic*. In: Gilovich T., Griffin D. and Kahneman D. (eds), Heuristics and biases: the psychology of intuitive judgment, Cambridge University Press, New York, NY, USA, pp. 397-420.

Starr C.; 1969: *Social benefits versus technological risks*. Sci., **165**, 1232-1238.

Sjoberg L.; 2000: *Consequences matter, "risk" is marginal*. J. Risk Res., **3**, 287-295.

Sjoberg L., Moen B.E. and Rundmo T.; 2004: *Explaining risk perception. An evaluation of the psychometric paradigm in risk perception research.* Rundmo T. (ed), Norwegian University of Science and Technology, Department of Psychology, Trondheim, Norway, Rotunde 84, 33 pp.

Speranza E.; 2016: *Percezione e valutazione del rischio sismico nell'attuazione delle politiche di prevenzione.* PH.D. Thesis in Administration and Behavioural Science, II edition, National School of Administration (SNA), Luiss - University School of European Political Economy, 49 pp.

Stanovich K.E. and West R.; 2000: *Individual differences in reasoning: implications for the rationality debate?* Behav. Brain Sci., **23**, 645-726.

Sunstein C.R.; 2003: *Beyond the precautionary principle*. University of Pennsylvania Law Review, **151**, 1002-1058.

Sunstein C.R.; 2013*: Nudges.gov: behavioural economics and regulation*. In: Zamir E. and Teichman D. (eds), The Oxford Handbook of Behavioural Economics and the Law, Oxford University Press, Oxford, UK, 840 pp.

Sunstein C.R. and Hastie R.; 2014*: Wiser*: *getting beyond group think to make group smarter*. Harvard Business Review, Boston, MA, USA, 272 pp.

Thaler R.H. and Sunstein C.R. (eds); 2008: *Nudge: improving decisions about health, wealth, and happiness.* Yale University Press, New Haven, CT, USA, 293 pp.

Thaler R.H., Kahneman D. and Knetsch J.L.; 1991: *Experimental tests of the endowment effect and the coase theorem*. In: Thaler R.H. (ed), Quasi rational economics, Russell Sage, New York, NY, USA, pp. 167-188.

Tobriner S.; 1983: *La casa baraccata: earthquake-resistant construction in 18th-century Calabria*. J. Soc. Archit. Hist., **42**, 131-138.

Tversky A. and Kahneman D.; 1974: *Judgment under uncertainty. Heuristics and biases*. Sci., **18**5, 1124-1131.

Tversky A. and Kahneman D.; 1981: *The framing of decisions and the psychology of choice*. Sci., **211**, 453-458, doi:10.1126/science.7455683.

United Nations Office for Disaster Risk Reduction (UNISDR); 2009: *UNISDR terminology on disaster risk reduction*. United Nations International, Strategy for Disaster Reduction, Geneva, Switzerland, 31 pp.

Valtieri S. (a cura di); 2008: *28 dicembre 1908. La grande ricostruzione dopo il terremoto del 1908 nell'area dello Stretto*. Clear, Roma, Italy, 1284 pp.

Vaughan E. and Vaughan T.; 2013: *Fundamentals of risks and insurance*, *11th edition*. Wiley & Sons Inc., Hoboken, NJ, USA, 688 pp., ISBN: 978-1-118-53400-7.

Viale R.; 2009: *Verso una behavioural Public Administration*. Scienze cognitive e amministrazione pubblica. Sistemi Intelligenti, **XXI**, 3-11.

Weber E.U.; 1997: *Perception and expectation of climate change: precondition for economic and technological adap*tation. In: Bazerman M., Messick D., Tenbrunsel A. and Wade-Benzoni K. (eds), Psychological Perspectives of Environmental and Ethical Issues in Management, Jossey-Bass, San Francisco, CA, USA, pp. 314-341.

Weinstein N.D.; 1980: *Unrealistic optimism about future life events*. J. Pers. Soc. Psychology, **39**, 806-820.

Zhang X., Liu Y., Chen X., Shang X. and Liu Y.; 2017: *Decisions for others are less risk-averse in the gain frame and less risk-seeking in the loss frame than decisions for the self*. Front. Psychology, **8**, 1-10, doi:10.3389/fpsyg.2017.01601.

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