



Special section paper

Rethinking current models in social psychology: A Bayesian framework to understand dramatic social change

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Dramatic social change (DSC) is the new normal, affecting millions of people around the world. However, not all events plunge societies into DSC. According to de la Sablonnière (2017, *Front. Psychol.*, 8, 1), events that have a rapid pace of change, that rupture an entire group's social and normative structures, and that threaten the group's cultural identity will result in DSC. This perspective provokes important unanswered questions: What is the chance that a DSC will occur if an event takes place? And, when will other societal states arise from such events? Addressing these questions is pivotal for a genuine psychology of social change to emerge. The goal of this article was to describe a methodology that attempts to answer these questions via a probabilistic decision tree within a Bayesian framework. According to our analysis, a DSC should occur 6.25% of the time that an event takes place in a stable society (68.75% of the time for incremental social change, 12.5% for inertia, and 12.5% for stability). The Bayesian probabilistic decision tree could be applied to specific event and thus serve as a guide for a programmatic study of social change and ultimately inform policymakers who need to plan and prepare for events that lead to DSC.

The most important challenges of our world are associated with unavoidable dramatic social change (DSC). Despite this, social psychology as a discipline is not positioned to address these challenges. As a scientific field, the explicit goal of social psychology is to provide a bridge between macro (the social context) and micro (individual) processes. Thus, some of social psychology's most important theories refer to how the social context of individuals, reflected in the social norms (Cialdini, Reno, & Kallgren, 1990), characteristics of a group (Tajfel & Turner, 1986), and social roles (Zimbardo, 2007) impact individual's behaviours and thoughts. By establishing the social context as the key element unlocking our understanding of individual process, social psychology possesses the theoretical tools necessary to understand the consequences of DSC at the individual level. And yet, despite its theoretical premises, social psychology as a field has been

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criticized for assuming that societal or group contexts are stable rather than dynamic (de la Sablonnière, 2017; Gergen, 1978; Gough, McFadden, & McDonald, 2013; McDougall, 2015; Smith & Conrey, 2007). Indeed, the assumption of stability in the field is reflected in several prominent theories in social psychology that focus on the status quo (such as social dominance theory and system justification theory) rather than on social change itself (see Table 1). This is not to say that social psychology has exclusively focused on stability, as some of its important theories have been concerned with collective actions as a form of social change (e.g., Tajfel & Turner, 1979; see also Runciman, 1966). However, even Turner acknowledged social psychology's fixation with stability and labelled it the 'stability bias' (2006, p. 43). In his paper, he points out how the study of stability, as opposed to the study of social change, has limited the theoretical and practical implications of the field.

The goal of this article is to challenge the assumption in social psychology that the social context of individuals is stable. More specifically, we offer a method that would allow social psychology researchers to infer the actual social context (or societal state) when an event occurs. Inspired by a probabilistic decision tree model in the context of a recent review of the literature of social change (de la Sablonnière, 2017), we propose a novel framework to measure and assess the probability that one of four identified societal states (DSC, incremental social change, inertia, and stability; see Table 2) will occur given an external event. Following the presentation of the proposed probabilistic tree, we will examine how our scientific reasoning based on a Bayesian framework is a non-conventional method in social psychology that may stimulate rethinking current models of social change.

Predicting which of four societal states will arise from an event is a crucial starting point for designing effective psychological strategies that promote successful adaptation. Most psychological strategies are designed specifically for stable societal contexts, which might make them ineffective when the societal context is marked by incremental social change, inertia, or DSC. Thus, the model we propose will hopefully encourage social psychology researchers to step away from their 'stable' bubble and into the complexities of conducting research in dynamic societal contexts.

The need for a psychology of social change

Hurricane *Irma* in 2017 transformed the lives of 50 million people by destroying some or all of their social infrastructures and homes. Some, like one mother in Saint Maarten whose 2-year-old child died, lost everything including their loved ones. Others must find a new home, sometimes in another country, and rely on government aid that comes ever so slowly to them. *Irma* exemplifies DSC and its consequences. DSCs, however, involve much more than natural disasters and climate change; they include disasters caused by humans, such as the wars, nuclear weapons, terrorist attacks, and genocides that threaten the social safety nets crafted by modern societies. DSCs also include the acceleration of technological change, mass migration of individuals, and the political decisions that demand a profound reorganization of the social structures in which people live, such as dismantling the USSR. Even events viewed by many as largely positive, such as the ending of Apartheid, involve DSC, as they provoke widespread uncertainty. In short, DSC plunges countries, nations, groups and individuals, rich and poor into a state of *collective trauma* where much adaptation is required.

Table I. Theories and perspectives addressing social change

Theory	Perspective on social change	Key authors
In social psychology		
Social identity theory (SIT)	Social identity relies on two aspects that may be associated with social change. First, SIT is a theory of social structure that is based on perceptions of legitimacy, stability, and permeability. Second, SIT proposes identity management strategies such as collective action whereby minority groups aim to maintain or acquire a positive and distinctive social identity.	Tajfel and Turner (1986)
Social dominance theory (SDT)	SDT posits that human societies follow their evolutionary drive to organize themselves in group-based social hierarchies. SDT makes use of social dominance orientation (or SDO), a personality trait in which individuals are prone to hierarchy-enhancing (high SDO) or hierarchy-attenuating (low SDO) attitudes. SDO explains who will show opposition vs. endorsement of social change.	Sidanius and Pratto (1999), Sidanius, Pratto, Van Laar, and Levin (2004)
Relative deprivation theory (RDT)	RDT can be applied to social change in two distinct ways. First, collective relative deprivation occurs when people compare their group to other groups and feel that their group is worse off, which will motivate them to improve their status by means of collective action. Second, in times of DSC, people are usually confronted with a unique situation that results in confusion and the loss of social cues. It is therefore easier and more relevant for them to compare their group's present situation to their group's status at another well-defined time period than to compare their group with another group. Recent research proposes the use of a historical trajectory when assessing one's group's collective relative deprivation.	de la Sablonnière, Auger, Sadykova, and Taylor (2010), de la Sablonnière, Taylor, Perozzo, and Sadykova (2009), Runciman (1966)
Immigration and identity integration (III)	Immigration is a form of social change that requires human adaptation. Research in this field has demonstrated that individuals who simultaneously identify with their culture of origin and with the receiving group's culture and also desire contact with both cultures experience the highest levels of well-being.	Amiot <i>et al.</i> (2007), Benet-Martínez and Haritatos (2005), Berry (2005)
Identity process theory (IPT)	IPT explores the structure of an individual's identity and the coping strategies used when facing an identity threat or change that results from social change.	Breakwell (1986)
System justification theory (SJT)	SJT is a theory, which postulates that both advantaged and disadvantaged members of	Jost <i>et al.</i> (2004)

Continued

Table 1. (Continued)

Theory	Perspective on social change	Key authors
	society tend to defend existing social, economic, and political structural arrangements. Thus, system justification represents people's motivation to perceive the social structure as good, fair, legitimate, and deserved. It is a theory that explains stability rather than social change.	
Identity threat theory (ITT)	In ITT, when a threat to identity occurs as a result of social change, individuals will regulate the structure of their identity by restoring the imbalance and modifying their identity through different processes that include integrating the new elements into their identity and assigning a positive or negative valence to them.	Steele et al. (2002)
Adjustment to change theory (ACT)	ACT considers how individuals adjust to social change and argues that factors such as social support and the nature of the event predict the way individuals and groups evaluate social change.	Goodwin (2006)
In subfields of psychology		
Cultural and evolutionary psychology	Focuses on how social change and human biology are linked and aims to identify how social change influences human genetics and the way humans adapt to these changes.	Feldman and Laland (1996), Laland, Odling-Smee, and Feldman (2000)
Developmental psychology	Research in this field has demonstrated that social change has the potential to impact developmental stages for children and adolescents as well as their identities and well-being.	Greenfield (2009, 2016), Pinquart and Silbereisen (2004)
Industrial/organizational psychology	Focuses on organizational change as a form of social change. Three main themes emerge from this field: how to successfully implement organizational change, how to limit the negative impact of organizational change, and how to understand the psychological processes of people who are confronting organizational change.	Burke and Litwin (1992), Kanter (1991), Meyer and Allen (1997), Reichers, Wanous, and Austin (1997), Sanzgiri and Gottlieb (1992)

Note. This table is an adaptation from de la Sablonnière (2017).

The field of psychology has long studied how people adapt to trauma when faced with personal change, whether it results from abuse (e.g., Raby, Labella, Martin, Carlson, & Roisman, 2017), from fighting in a war (e.g., Lee, Possemato, & Ouimette, 2017), or, similar to the mother in Saint Maarten, from losing a loved one (e.g., Stroebe, Schut, & Boerner, 2017). Even positive life-changing events (e.g., a wedding or the first instance of self-disclosed sexual identity; see Coulombe & de la Sablonnière, 2015; Riskind, Kleiman, & Schafer, 2013) trigger stress mechanisms akin to those of negative events. However, when DSCs occur, that is, when every single individual in a community is touched by an event, the psychology of the individual may be insufficient to understand this *collective trauma*. The childless mother in Saint Maarten is not the only one who has lost all; her neighbours, her family, and everyone in the community have experienced concurrently traumatic events.

Table 2. The typology of social change

Societal contexts	Definition
Stability	A situation where an event, regardless of its pace, does not affect the equilibrium of a society's social and normative structures nor the cultural identity of group members. The event, may, however, impact an isolated number of individuals.
Inertia	A situation where an event, regardless of its pace, does not either reinstate the equilibrium of a society's social and normative structures or clarify the cultural identity of group members.
Incremental social change	A situation where an event leads to a gradual but profound societal transformation and slowly changes the social and/or the normative structure or changes/threatens the cultural identity of group members.
Dramatic social change	A situation where a rapid event leads to a profound societal transformation and produces a rupture in the equilibrium of the social and normative structures and changes/threatens the cultural identity of group members.

Note. This table is an adaptation from de la Sablonnière (2017).

The fact that a group experiences collective trauma does not negate the resilience of certain individuals (Bonnano, 2004), nor the fact that the DSC might be perceived as a positive and necessary event by specific subgroups (e.g., when revolutionaries overthrow a government; de la Sablonnière, French Bourgeois, & Najih, 2013). Nevertheless, while such individuals and subgroups may be resilient to trauma in their personal lives, they cannot escape the fact that their collectivity is experiencing trauma, as most of the people around them are deeply touched and in dire need of adaptation. When DSC and collective trauma occur, *individual* psychology may be insufficient to understand the adaptation processes of whole collectivities. This is where social psychology, the field that studies how contextual and collective issues impact individuals, can play an important and critical role in understanding the emergence, treatment, and prevention of collective trauma following a DSC.

Defining dramatic social change in psychology

While social change has been a central domain of study in the field of sociology (e.g., Durkheim, 1893/1967; Sztompka, 1993; for a recent review, see de la Sablonnière, 2017), social psychology did not follow the same path. Even though social psychology arose out of the need to understand the emergence of dramatic social changes, such as the Jewish holocaust and the unwavering obedience of SS guards (Zimbardo, 2007), social change never took off as an important subject for social psychology. To the best of our knowledge, the term *social change* first appeared about seventy years ago in the *Annals of the American Academy of Political and Social Science* in an article that was entitled *Psychology of Social Change* (Marquis, 1947). After this article, there have been few attempts to revive both the concept and the study of social change in the field of psychology (e.g., Pizer & Travers, 1975; Schneiderman, 1988; see de la Sablonnière, 2017).

For those few social psychologists interested in social change (see Table 1 for the main theories associated with social change in psychology), the fundamental question to answer is: *What are the psychological consequences of social change for individuals?* To

study this question, many researchers equated social change to collective actions. This is particularly the case for social identity theory (Tajfel & Turner, 1986) and relative deprivation theory (Runciman, 1966), two influential theories in social psychology. In these theories, social change occurs when minority group members or disadvantaged group members fight to improve the situation or status of their group (Batel & Castro, 2015; de la Sablonnière *et al.*, 2013; de Lemus & Stroebe, 2015; Taylor & McKirnan, 1984; Wagoner, Moghaddam, & Valsiner, 2018). Other social psychology researchers focused less on social change itself, and instead focused on how social change impacts the identity of group members (Amiot, de la Sablonnière, Terry, & Smith, 2007; Benet-Martínez & Haritatos, 2005; Breakwell, 1986; Steele, Spencer, & Aronson, 2002). For example, Amiot *et al.* (2007) created a model to explain the process by which individuals integrate new social identities when changes, such as immigration, bring them in contact with new groups.

Nevertheless, the social psychological approaches to social change described above and presented in Table 1 are limited theoretically and methodologically. Theoretically, social stability and how to maintain it is more often the focus, as opposed to a social change itself (e.g., Turner, 2006). Methodologically, social psychology has long held experimental methodologies to be the gold standard. As social change is very difficult to study under the controlled settings of a laboratory (Moghaddam & Crystal, 1997; de la Sablonnière *et al.*, 2013), this methodology prevented many social psychologists from focussing on the pressing issues associated with social change. Instead, the methodologies and statistical analyses currently employed in social psychology take for granted that individuals are in stable and unchanging contexts (Moghaddam, 2018; Smith & Conrey, 2007). This assumption of stability is further ingrained by the populations used in social psychological research, namely university students from Western, Educated, Industrialized, Rich, Democratic (WEIRD; Henrich, Heine, & Norenzayan, 2010), and mostly stable societies.

These methodological and theoretical limitations have culminated in a limited definition of social change. More specifically, social psychology has articulated social change almost exclusively in terms of collective action. This disregards the fact that social change is often out of the control of individual group members; politicians take important decisions without the accord of their constituents, environmental events may strike anywhere without mercy, and technological advances can be made without conscious awareness of laypeople. Unlike the concept of collective action, social changes are often outside of our control. Furthermore, those researchers who have focused on the consequences of change in psychological identity have rarely defined and operationalized 'change' itself. As such, it is unclear what are the macro-level variables of change, or even the type of change itself, that demand adaptation. While a few social psychology theories have examined social change and defined it more broadly (see de la Sablonnière, 2017), these attempts remain the exception; the rule in social psychology is to reduce the operationalization of social change to its bare minimum. This reductionist approach disables social psychology from truly studying the different dimensions of social change, along with how individual group members adapt to these changes. To move beyond a simplistic conceptualization of social change, the field of social psychology requires a definition of social change that maintains an individual focus while also placing macro, large, and social contexts at the heart of social change.

Such a definition has recently been attempted by de la Sablonnière (2017). After reviewing more than 5,000 abstracts (and 325 papers) and identifying the main characteristics of DSC discussed in the psychological and sociological literature, a

Table 3. Characteristics of dramatic social change

Characteristics	Values	Definition
1 The pace of change (PC)	Rapid Slow	The speed at which an event impacts a collectivity.
2 Rupture in the social structure (RSS)	Yes No	A break with the past so that even core aspects of society such as social institutions have to be reconstructed; a society undergoes a complete transformation.
3 Rupture in the normative structure (RNS)	Yes No	A break with the past in terms of the core behaviours of the group members that now have to be modified significantly in order to achieve collective goals.
4 Cultural identity threat (CIT)	Yes No	A serious threat to identification and to the clarity of the shared beliefs, values, attitudes, and behavioural scripts associated with one's group.

Note. The definitions in this table are from de la Sablonnière (2017).

typology of social change was developed. First, this typology identified DSC as one of four possible societal states, the other states being stability, inertia, and incremental social change (see Table 2 for the definitions). These societal states represent the situation of a social group at any given time.

Second, the typology offered a definition of DSC. Specifically, DSC was defined as requiring four essential characteristics: It requires a rapid pace of an event, it ruptures the social structure, it ruptures the normative structure, and it threatens (or changes) the cultural identity of the group (see Table 3 for the definitions). These four characteristics are necessary conditions for a societal state of DSC. If one or more of the four characteristics of DSC are absent, then one of the three other possible societal states will result: stability, inertia, or incremental social change.

In this article, the general term *social change* refers to the transition from any one societal state to another, such as moving from stability to DSC or from DSC to stability, and so on. Such a shift in societal state results when an important event occurs. An *event* is any development, action, or incident that triggers a shift in societal state. Our use of the term 'event' is consistent with previous literature, where events have the potential to lead to social change (Sewell, 1996). An event may be real (such as a hurricane) or illusory (such as the framing of crime rate or immigration rate so that they seem more striking). Any event, even small ones such as the *butterfly effect*, has the potential to trigger a change from one societal state to another. However, it is not because an event occurs that a society will shift from one societal state to another (i.e., experience social change).

By identifying the four characteristics of DSC that are agreed upon in the literature, the systematic review (de la Sablonnière, 2017) represents the first step towards better understanding the psychology of social change. More specifically, the review offers a concrete framework that allows researchers to better understand the meaning of DSC and its consequences. For example, these four characteristics may be used to predict how group members develop coping mechanism following an event that leads to DSC, inertia, or incremental social change. They may even be useful to create experimental methodologies, as researchers manipulate the characteristics of social change and examine their consequences on individuals' well-being.

However, the psychology of social change is still in its infancy and much needs to be learned regarding how individuals cope with social change. One question that is urgent to

answer in our ever-eventful world concerns the probability of any event resulting in a specific societal state. If a rapid external event occurs, what is the probability that a particular society will shift to another societal state? For example, if a terrorist attack takes place tomorrow in Germany and destroys the German parliament, what is the probability that Berlin, or Germany, would shift from stability to DSC? If this attack took place in the United States, the UK or Russia, would the probability of a DSC occurring be the same as one that targeted Germany? Even though the typology of social change was essential for defining DSC, it does not consider how different events can lead to different societal states depending on the context in which they take place.

For example, Hurricane *Irma* affected Saint Maarten and Florida with a very different probability of DSC occurrence, even though it hit with similar strength of wind gusts and rain. From news reports, it is clear that Saint Maarten or Puerto Rico’s situation after hurricanes *Irma* and *Maria* can probably be considered as DSC, whereas these hurricanes did not leave Florida in a state of DSC; the same rapid event may have ruptured the normative and societal structures in one society but not in the other.

We argue that a probabilistic framework is needed to understand when societies may face the challenge of DSC when a rapid and dramatic external event takes place. Using such an approach, we examine how a Bayesian framework, or more specifically a Bayesian decision probabilistic tree, may be useful to assess such a shift in societal states, or the process of *social change*, given a specific event. Thus, we move beyond definitions of societal states (see Figure 1).

A probabilistic decision tree model

As the foundation of statistics, probability is used every day across many scientific disciplines, including psychology, but also in our personal lives, whether we are scientist or layperson, to function in our social world. We navigate the world by predicting the

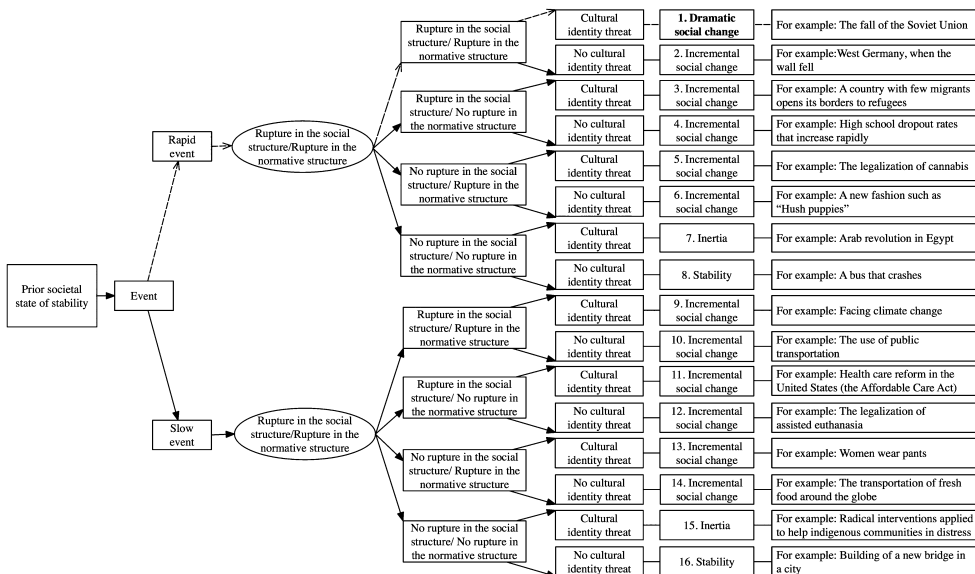


Figure 1. The probabilistic decision tree with the prior societal state of stability. The dotted lines are those where the path leads to dramatic social change.

occurrence of events based on our past experiences and current assumptions. Such navigation can be illustrated with a probabilistic decision tree (e.g., Figure 1), which explores all possible discrete states that can be reached by a multidimensional variable with a nonzero probability. Each particular binary decision (or variable) is of Bernoulli type with a 'yes or no' value (see Table 3).

For example, every time we engage in an action, we tend to predict the most probable outcome, given the sequence of variables that may interact with it. If a child deviates from his normal behaviour (e.g., he puts his hands inside his T-shirt and pretends that he is an armless monster, running around without the balance provided by his arms), his parent will examine the situation and analyse whether the child is likely to fall (yes or no); if he is likely to fall, the parent then analyses the chances that the child would hurt himself badly enough that he will need to go to the hospital (yes or no). If there is low probability that falling down will result in a serious injury, then the parents might let the child play in this unusual way, letting him experience this challenge and, hopefully, learn from it. If, in the parent's mind, the behaviour has a nonacceptable probability of becoming dramatic, the parent will intervene.

In making a decision about the child, the parent used what is commonly called a probabilistic decision tree based on the characteristics observed during the event. Intuitively, the parent was analysing the situation based on an initial 'subjective belief' or in Bayesian terms, an *a priori* state. These subjective beliefs depend on characteristics proper to the environment (e.g., how dangerous the room is), the culture (e.g., a culture in which children are highly restrained), and the individual (e.g., overprotective parenting style). The parent hence stands at the first branch of the tree (will the child fall? Yes or no) while holding an *a priori* state. Following this initial branching, a second branching occurs as the parent wonders whether the injury would be serious (yes or no). In this example, there is a causal sequence of observations: the behaviour, the risk to fall, the chance of great injury. There is a statistical dependence between these characteristics, and the decision tree should take into account this interdependence.

This probabilistic decision tree may become increasingly complex by adding further branches (e.g., does the child have experience running without the use of his arms? Yes or no; is the parent a doctor? Yes or no). The probabilities in the branch will also depend on how the context in which this event would occur is perceived (e.g., how dangerous the room is perceived to be). Thus, the tree is created in terms of a specific context, which may influence the probability that the parent will intervene and ask the child to stop.

In this article, we argue that such a decision tree may be applied to societies and more specifically to determine when an event will lead to a DSC. The characteristics of DSC previously identified (de la Sablonnière, 2017) can constitute the branches for the decision tree, which allow for the inference of a *posteriori* societal state, given an event and an initial *a priori*.

A probabilistic decision tree and DSC: The Bayesian framework

In this section, we analyse whether an event, assessed through the observation of four characteristics (pace of change, rupture of social structure, rupture of the normative structure, and the cultural identity threat) will end up in a specific societal state (DSC, incremental social change, inertia, stability). We first note that the resulting societal state can be seen as a latent variable not directly measured, as we are predicting its probability

of occurrence. The four observable characteristics can be observed, measured, and used to predict the expected *a posteriori* societal state.

From a probabilistic point of view, this prediction about the societal state can be formulated as an inference (i.e., *a posteriori* inference) based on the observations of the characteristics and the *a priori* assumptions about the current societal state. The Bayesian formalism is the appropriate approach to answer this inference problem, as this formalism uses observations to correct the *a priori* assumptions, those made on the current social state prior to taking into account the observations *per se* (e.g., Bernardo & Smith, 2000).

We first define the joint probability of a resulting societal state or 'state' and the characteristics (i.e., the observations that can be measured): $p(\text{state}, \text{characteristics})$. This expression represents the probability that a state and the characteristics occur together, for example, the probability that a DSC occurs along with a rapid pace of change, the rupture of the social and normative structures, and a threat/change to the cultural identity.

This probability can be written in terms of a product that exhibits a *conditional* probability over one of the variables, or a variable that acts as an observed value against which the probability of the other variable is defined. In our case, the occurrence of a DSC has a *conditional probability* that depends on the observation of the four characteristics. Two possible writings emphasize which variable can condition the other one (the *condition* is the variable after the vertical bar in the formulas):

$$\begin{aligned} p(\text{state}, \text{characteristics}) &= p(\text{state}|\text{characteristics}) p(\text{characteristics}) \\ &= p(\text{characteristics}|\text{state}) p(\text{state}) \end{aligned}$$

The well-known Bayesian formula derives from the last equality:

$$p(\text{state}|\text{characteristics}) = \frac{p(\text{characteristics}|\text{state}) p(\text{state})}{p(\text{characteristics})}$$

where

$$p(\text{characteristics}) = \sum_{\text{state}} p(\text{characteristics}|\text{state}) p(\text{state})$$

is a summation over all possible reachable societal states.

On the right side, $p(\text{state})$ represents the *a priori* probability of the current societal state. The probability $p(\text{state}|\text{characteristics})$ represents the same probability but once the observed characteristics are taken into account. The correction term that updates this probability and leads to the *a posteriori* inference is a ratio that concerns the characteristics. The four characteristics PC, RSS, RNS, CIT (see Table 3) can be explicitly described in the joint probability of the characteristics, emphasizing again which ones can drive (in a statistical causality sense) the others:

$$p(\text{characteristics}|\text{state}) = p(\text{CIT}|\text{RSS}, \text{RNS}, \text{PC}, \text{state}) p(\text{RSS}, \text{RNS}|\text{PC}, \text{state}) p(\text{PC}|\text{state})$$

A decision tree can help quantify this ratio. This three-level factorization can be well illustrated with a decision tree that explores all possible values that may be reached by combining the observed characteristics (see Figure 1).

This expression can be further simplified under particular assumptions. For example, in our current model we assumed that cultural identity threat may depend on the other characteristics, $p(\text{CIT}|\text{RSS}, \text{RNS}, \text{PC}, \text{state})$. This assumption could be revisited, as we may instead theorize that cultural identity threat is independent from the other characteristics, in which case the conditional probability over CIT would boil down to $p(\text{CIT}|\text{state})$. We would then end up with the following model:

$$p(\text{characteristics}|\text{state}) = p(\text{CIT}|\text{state})p(\text{RSS}, \text{RNS}|\text{PC}, \text{state})p(\text{PC}|\text{state})$$

It is worth noticing that the joint bivariate probability that addresses the rupture, either of the social structure or the normative one, can be recast in two ways, depending on the context of the change under concern:

$$p(\text{RSS}, \text{RNS}|\text{PC}, \text{state}) = p(\text{RSS}|\text{RNS}, \text{PC}, \text{state})p(\text{RNS}|\text{PC}, \text{state})$$

or

$$p(\text{RSS}, \text{RNS}|\text{PC}, \text{state}) = p(\text{RNS}|\text{RSS}, \text{PC}, \text{state})p(\text{RSS}|\text{PC}, \text{state})$$

The two forms are legitimate but they express two different situations in terms of modelling the causal relationship between the social and the normative structures. For instance, in the example of hurricane *Irma*, we may more likely choose the last factorization as the rupture in the normative structure seems conditional to the presence of a rupture in the social structure (and not the other way around).

The final formula expressing the decision tree model in Figure 1 is as follows:

$$\begin{aligned} & p(\text{state}|\text{characteristics}) \\ &= \frac{p(\text{CIT}|\text{RSS}, \text{RNS}, \text{PC}, \text{state})p(\text{RSS}, \text{RNS}|\text{PC}, \text{state})p(\text{PC}|\text{state})}{p(\text{characteristics})}p(\text{state}) \end{aligned}$$

where

$$\begin{aligned} & p(\text{characteristics}) \\ &= \sum_{\text{state}} p(\text{CIT}|\text{RSS}, \text{RNS}, \text{PC}, \text{state})p(\text{RSS}, \text{RNS}|\text{PC}, \text{state})p(\text{PC}|\text{state})p(\text{state}) \end{aligned}$$

The probabilistic decision tree illustrated in Figure 1 exemplifies all possible combinations of characteristics with the underlying state associated with each branch. This is a model in which the ‘transition probabilities’ from one level to another have to be defined. By transition probabilities, it is meant that the value for each branching is $p = .50$, or yes or no values. In our probabilistic decision tree, we used the four characteristics of social change – as defined in the typology of social change – to predict the probability of occurrence of DSC as well as the three other societal states (see Tables 2 and 3). Based on the four characteristics and their definitions, there are a total of 16 possible combinations (see Figure 1 and Table 4), where only one represents DSC ($p = .0625$ if all ‘transition probabilities’ are identical), according to the definitions offered by de la Sablonnière (2017).

A real-world example of DSC would be the breakdown of the Soviet Union, the destruction of Mosul and hurricane Irma in Saint Maarten. In these three instances, the event that took place was rapid, there was a breakdown in both the normative and the social structures of the groups, and the cultural identities of these groups were either changed or significantly threatened.

According to our model, an event would result in incremental social change at a probability level of $p = .6875$. For an incremental social change to occur, at least one of the four characteristics needs to be present. For example, the fall of the Berlin wall for West Germany had three of the four characteristics of social change; the change was rapid in pace, their social and normative structures changed drastically, but their identities as Germans were not threatened, as it was the case for East Germans. Other incremental social changes can have a combination of two characteristics (e.g., the development of public transportation in a city without public transportation) or just one characteristic (e.g., the transportation of fresh food around the globe).

Our analysis also shows that inertia can follow an event at a probability level of $p = .125$. An example of such an event would be a governmental intervention expected to drastically improve the situation of a suffering indigenous community but when the intervention (i.e., the event) occurs, it does not rupture the social and normative structures of the group as it was expected, and instead, it threatens their cultural identities.

Lastly, the model shows that stability should occur at a probability level of $p = .125$. An event that results in stability could be a big car accident that results in part of the city's highway being closed for a few hours. While such event might be fast and result in important deaths, it is not fracturing the normative and social structures of the group, nor is it threatening their cultural identities.

The probabilistic tree presented in Figure 1, however, is subject to the same criticism as social psychology so far; it takes for granted that a society is in a state of stability when an event takes place. This assumption is unwarranted, given that events triggering DSC can occur in places that are already unstable. The reason why hurricane *Irma* devastated Saint Maarten far more than Florida might be because Saint Maarten was in a societal state that was not stability when the hurricane stroke, while Florida experienced the event from a stable societal state.

To address this criticism and highlight the importance of considering the context, Figure 2 illustrates the decision tree from an initial state of incremental social change. When an event is considered in a state experiencing incremental social change (*a priori* assumption), the *a posteriori* state of DSC is far more probable ($p = .25$), with different combinations of characteristics leading to DSC, compared to when stability is the *a priori* assumption (see Table 4).

Theoretical assumptions

The aim of our article was to propose a new methodology, inspired from applied mathematics, to facilitate reconceptualizing the role of the social context, and more specifically of DSC, in current theories and models in social psychology. Specifically, a recent review article on the psychology of social change identified four well-established societal states (de la Sablonnière, 2017). This article proposed that the state of a society depends on the presence or absence of four characteristics (i.e., rapid pace of change, rupture of social structure, rupture of the normative structure, and threat to cultural

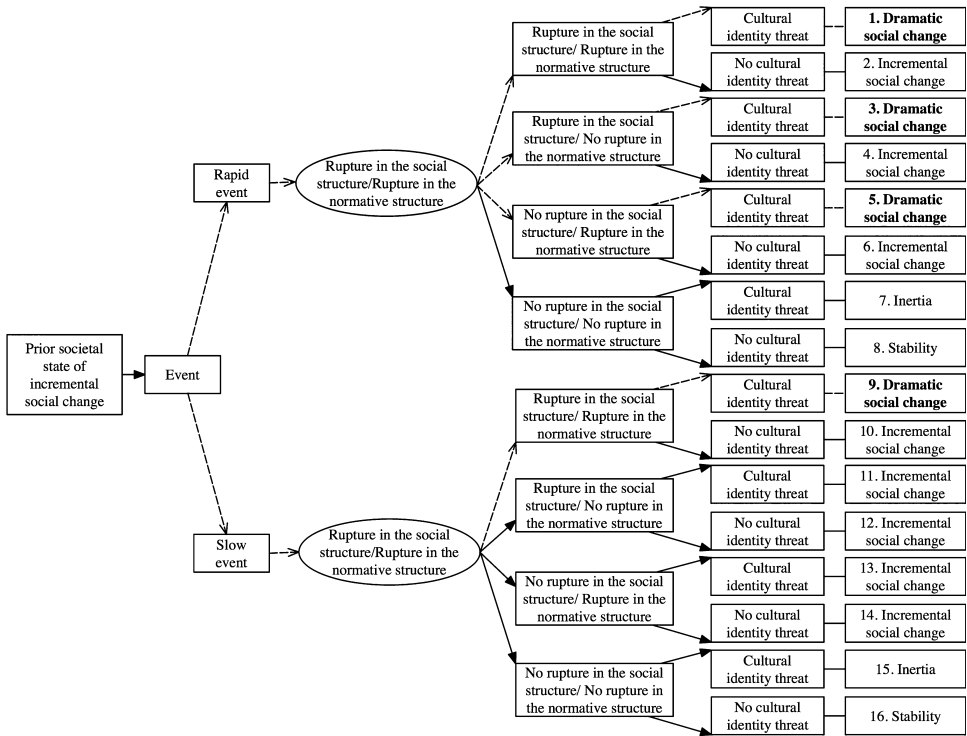


Figure 2. The probabilistic decision tree with the prior societal state of incremental social change. The dotted lines are those where the path leads to dramatic social change.

identity). Given that all four characteristics need to be present for a DSC to take place, we argued that a probabilistic decision tree could be used to assess the probability of this societal state resulting from a specific event. Our analysis suggests that when an event takes place in a state of stability, a shift to a state of DSC may occur 6.25% of the time, 12.5% for inertia, 12.5% for stability, and finally, 68.75% of the time for incremental social change. Different probabilities may result from starting from different *a priori* societal states, as reflected in Figure 2 and Table 4.

The obtained probabilities of occurrence were based on a decision tree designed with two main assumptions. The first assumption arises from the typology of social change (de la Sablonnière, 2017) where the four characteristics of social change are *not* independent from each other. This is important to acknowledge as it influences the way in which the equations are formalized in the article. Specifically, for a DSC (or for other societal states) to be defined as such, a rapid event needs to have affected the social or normative structures. In addition, the threat to cultural identity is a consequence of the three previous characteristics, as it is more likely to occur when an event is rapid and when there is rupture in the social and normative structures. Figures 1 and 2 illustrate the interdependence of these four characteristics.

Second, we further conjecture that the decision tree is able to take into account the subjective perspective of individuals because it uses the Bayesian framework. According to Bayes' theorem, subjective perspectives arise from the uncertainty of the world. Bayes' theorem is designed to handle how this uncertainty is perceived. For example, Bernardo and Smith (2000) wrote that 'Bayesian Statistics offers a rationalist

Table 4. Probabilities of occurrences

	<i>A priori</i> societal states			
	Stability		Incremental social change	
	Tree branches	p	Tree branches	p
<i>A posteriori</i> societal states				
DSC	1	.0625	1, 3, 5, 9	.25
Incremental social change	2, 3, 4, 5, 6, 9, 10, 11, 12, 13, 14	.6875	2, 4, 6, 10, 11, 12, 13, 14	.50
Inertia	7, 15	.125	7, 15	.125
Stability	8, 16	.125	8, 16	.125

theory of personalistic beliefs in contexts of uncertainty' (p. 4) and specify that Bayesian Statistics are concerned with the '*logical process of decision making in situations of uncertainty*' (p. 15).

The way in which the Bayesian framework accounts for subjectivity is reflected in three specific aspects of the decision tree. First, in Bayesian statistics, the *a priori* is a subjective assumption based on the perception of information without an objective assessment (e.g., Jackman, 2009). In the current model, the *a priori* represents the perception one has about the societal state at the time of an event. This subjective *a priori* information will be updated in response to the observable data, or the four characteristics of DSC.

The second way in which our model takes into account subjectivity is based on the fact that the transition probabilities may change according to the individual that assigns them (e.g., the policy analyst, the researcher). In the current paper, each of the decision values for the characteristics was based on an equal transition probability ($p = .50$) for each branch of the decision tree (e.g., yes or no binary values; see Table 3). This conceptualization is limited in that a more informative probability configuration might not be uniform (e.g., $p = .10$ for a rapid pace and $p = .90$ for a slow pace), depending on how the probabilities are assigned. For example, if one uses a lifetime perspective (the last 100 years) versus an historical perspective (the last thousands of years), means of communications may be perceived as rapid (historical) or slow (lifetime) with a different probability with respect to the perspective. Similarly, different subgroups may use different transition probabilities. If we were to evaluate the end of Apartheid, transition probabilities could be differently appointed by Africans, Afrikaners, White or Coloured for each of the four characteristics or even within each group depending on some individual or demographic factors (e.g., see de la Sablonnière et al., 2013).

Finally, the third way in which the subjective assumptions are accounted for in the current model concerns the fact that the decision tree may be hierarchical. A hierarchical model means that there is a probability *distribution* associated with each branching of the tree (Bernardo & Smith, 2000). In this perspective, the probability p for each transition may be a stochastic parameter (i.e., involving a random parameter). In other words, the distribution of the probability p may vary more or less depending on the level of certainty that may be attributed for each transition probability. If there is a strong agreement about whether an event (e.g., a hurricane) is rapid versus slow, the distribution of p can have a small variance in that most people agree with the speed of the event. In contrast, if there is

considerable disagreement as to whether an event (e.g., women's rights) can be considered rapid versus slow, this uncertainty will be reflected in the larger variance of the p distribution.

Theoretical, methodological, and practical implications: Rethinking current models in social psychology

The current model offers a theoretical and methodological foundation from which the field of social psychology can build as it moves towards a focus on the psychology of social change. Because social change remains such a complex entity (Buchanan *et al.*, 2005; McGrath, 1983; Subašić, Reynolds, Reicher, & Klandermans, 2012), the definitions and the examples that we described must be questioned, debated, and improved upon to better address the specific social contexts, the theoretical zeitgeist, and the methodological approaches that are constantly changing. While we acknowledge the difficulty in defining, giving examples, and studying DSC, along with the potential improvements to our model, we consider that the field of social psychology is at present too narrow in its study of social change, making it urgent to begin a conversation on broader and alternative theoretical and methodological views. It is this sense of urgency that motivated us to propose the probabilistic tree, even at the risk of missing the 'best' exemplars for the probabilistic decision tree in Figure 1 or of having a more optimal model (e.g., one with transition probabilities different than $p = .50$).

Indeed, a more informative probability configuration might not be uniform (e.g., $p = .10$ for a rapid pace and $p = .90$ for a slow pace). To address this specific limit of the proposed ideas, worldwide events that have already taken place could be modelled, as well as the societal state that resulted. If we determine that across several worldwide events a rapid event occurs 5% of the time, this information can then be used to make the decision tree model more reliable, thus optimizing its predictive ability when a new event does occur. Using theoretical arguments and/or empirical evidence, researchers can learn about, and adjust, the probability of occurrence of the four characteristics of DSC. They can also adapt the model in real time, based on the new data offered by current societal events.

While the probabilistic tree might have its limits, our main theoretical contribution directly addresses one of the fundamental criticisms addressed towards the field of social psychology: Social psychology is static and not dynamic (e.g., Gergen, 1978; Smith & Conrey, 2007). More specifically, social psychological theories take the social context as a stable entity while the interactions between a changing society and changing individuals are too often neglected. In contrast, our theoretical and mathematical approach conceptualizes DSC as but one of four societal states, which allows social psychologists to place individuals within their social contexts while simultaneously acknowledging that these contexts may shift from one state to another. In other words, societies are not always in a state of stability. In fact, most of the time an event will induce a state of DSC, incremental social change, or inertia, three states that are very different from stability; based on our current model as illustrated in Figures 1 and 2, there is only a 12.5% chance that a stable societal state will be the result when an event takes place, which means that 'stability' is far less constant than is currently assumed. This alone is sufficient to question the way in which the field approaches the study of social change more specifically, and of the social animal more broadly.

This assumption of ‘stability’ in the context is often taken for granted in social psychological theories and associated subfields in psychology that touch on social change (see Table 1). For example, one of the most prominent theories in Table 1 is system justification theory, which postulates that members of society have a tendency to defend or rationalize existing social, economic, and political structural arrangements (Jost, Banaji, & Nosek, 2004). Thus, system justification represents people’s motivation to perceive the social structure as good, fair, legitimate, and deserved (Jost & Hunyady, 2002). According to this theory, the motivation to justify the system is present even among disadvantaged group members, at the expense of their personal or collective well-being (Blanton, George, & Crocker, 2001; Jost, 1997; Jost & Thompson, 2000; Jost *et al.*, 2004; Major, 1994). These system justification explanations convince individuals that their social contexts are stable, understandable, predictable, consistent, and meaningful (Jost & Hunyady, 2002). Thus, at its very essence, system justification theory assumes that the stability of the context is the actual and desired status quo. Nevertheless, this assumption of stability makes it impossible to know, based solely on this theory, whether disadvantaged groups would be willing to justify an unfair system when contexts are unstable – such as in contexts of DSC or incremental social change – and thus when beliefs of stability would be much more difficult to achieve.

The assumption of stability is also reflected in social identity theory. Social identity theory was proposed to understand how group membership affects individual’s actions. To do so, it was postulated that individuals have a fundamental need to have a positive social self-view, which is achieved by belonging to groups with high status (Tajfel, 1975). When a group does not have a high status, social identity management strategies such as collective action will be engaged in to achieve a positive self-view (Tajfel, 1974, cited by Tajfel, 1975). Importantly, whether collective action (or other identity strategies) will be engaged in depends on three different socio-structural characteristics: stability, perceived legitimacy of group status, and permeability of group boundaries (Mummendey, Kessler, Klink, & Mielke, 1999). Thus, social identity theory places the stability or instability of the context at the heart of its theory. And yet, despite giving importance to the concept of stability as an *antecedent* of collective action, social identity theory remains silent as to the *resulting* stability of the context following collective action. Thus, while instability might result in collective action, it is unknown when this social change will bring back some form of stability in society (as in the stable tree, Figure 1), or whether it will leave the social structure sensitive to other events (as in the incremental social change tree, Figure 2). Thus, the assumption of stability in the context leads to the belief that collective action is the end game, whereas the consequences of this social change on the dynamic social context are ignored.

The fact that social psychology is dominated by static assumptions is also reflected in the methodologies chosen to test its theories as most social psychologists use a frequentist approach. The frequentist approach ignores the subjective or *a priori* information and rather focuses on rejecting null hypothesis uniquely from observable data (Gelman, 2018; Jackman, 2009). One notable exception of ‘dynamic’ research is the work by Smith and Conrey (2007) on agent-based modelling (or ABM), which reconceptualized how we think about human interactions. Before ABM, theories on group polarization (e.g., Isenberg, 1986; Myers & Lamm, 1976) expected that any successful persuasion would result in changes in individual’s attitudes towards the majority’s opinion, culminating in a uniform group opinion. An ABM approach allowed for the dynamic study of human interactions, so that researchers could better understand how attitudinal diversity persists over time. In the spirit of ABM, we offer social psychology an alternative methodology

based on a Bayesian framework, where we no longer need to assume that the context is stable, and instead, we can study the dynamic psychological processes involved in social change.

With the Bayesian model proposed, we hope to provide social psychology with a theoretical model to develop a genuine *psychology of social change*, where researchers can begin to study the unique psychological processes associated with each societal state, as well as those that are shared across states. For example, we may find that social support is widely available in contexts of stability and incremental social change, somewhat available in a state of DSC, but completely absent in inertia, as social support resources may have been consumed in these latter two societal states. Thus, the probabilistic decision tree allows social psychology to explore the psychology of each societal state so that they may be better understood. Furthermore, the model we propose encourages the psychological study of the process of social change, as researchers now have the tool to investigate the psychological mechanisms by which individuals adapt (or not) to transitions or changes in societal states.

Finally, this article has important practical implications to consider when developed to their maximal potential. Researchers and governments could use the proposed tool to forecast the forthcoming societal state of a given community when an important external event occurs. Experts could analyse the possibility that an event, fast or slow, will lead to a rupture in the social structure and/or of the normative structure and/or threat to cultural identity. If the four conditions are met, one can have some degree of certainty that a DSC will be the result; if not, analysts can predict the state in which society will find itself if the predictions are right. Once a new societal state is predicted, concrete and specific intervention tools may be deployed to support the victims and optimize both human and financial resources. An event that would lead to DSC in a society (e.g., hurricane *Maria* in Puerto Rico), as opposed to stability or incremental social change, would need more resources, both human and financial, to prevent collective trauma. In moving forward with the practical implications, a software has been developed in *MATLAB* to illustrate the methodology presented in this work and is available upon request.

Conclusion

Rethinking how we do social psychology in the context of social change becomes more and more necessary. Looking beyond the discipline of social psychology might be one means of improving current theories. In this article, we propose one way in which current social psychology models of social change can be examined from a mathematical perspective. To our knowledge, there are very few theoretical models that use a Bayesian framework in the field of social psychology (for a related example see Moutoussis, Trujillo-Barreto, El-Deredy, Dolan, & Friston, 2014). The use of a probabilistic framework as the one described in the current article has the potential to open even more doors in terms of reconceptualising the study of social change and possibly modern social psychology. Such Bayesian formalisms further our understanding on how the individual functions in a dynamic social context with the hopeful ambition of developing the psychology of social change. We argue that there is a strong need to apply methods able to test dynamic models of human process as they can better account for an ever-changing human in an ever-changing context.

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