social sciences

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The Affective Regulation of Uncertainty: The Semiotic Dimensionality Model (SDM)

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Abstract: This paper presents a novel psychological model of the socio-cognitive management of uncertainty, the semiotic dimensional model (SDM). The SDM claims that uncertainty increases the momentum of affect-laden meanings in meaning-making. This is so because affective meanings provide a simplified interpretation of the world that restores the experience of being able to make sense of the reality destabilized by uncertainty. Moreover, the SDM models the affective meanings in terms of low-dimensional mental phase space (MPS). Each dimension of the MPS detects a facet of the context. The lower the MPS dimensionality, the lower the number of facets of the context processed, therefore, the more simplified the meaning-making is. We attained the first empirical validation of the SDM in a sample of 120 Italian people. First, the SDM assumption that the low-dimensional MPS is the computational descriptor of affective meaning was tested. Second, an experimental study was designed in which uncertainty was manipulated so as to assess its effects on the dimensionality of participants' MPS. It was hypothesized that uncertainty induces a decrease in the MPS dimensionality. Results were consistent with both hypotheses. Theoretical implications of the SDM and its relationship with other theories are discussed and future research direction outlined.

Keywords: uncertainty; semiotic dimensionality model; affective pertinentisation; attitude towards foreigners; ethnic identity; punitive attitude

Citation: Salvatore, Sergio, Terri Mannarini, Alessandro Gennaro, Giovanna Celia, Serena De Dominicis, Raffaele De Luca Picione, Salvatore Iuso, Skaiste Kerušauskaitė, Johann Roland Kleinbub, Arianna Palmieri, et al.. 2023. The Affective Regulation of Uncertainty: The Semiotic Dimensionality Model (SDM). *Social Sciences* 12: 217. https://doi.org/10.3390/socsci12040217

Academic Editors: Belinda Winder and Nigel Parton

Received: 28 December 2022
Revised: 27 March 2023
Accepted: 28 March 2023
Published: 5 April 2023

1. Introduction

1.1. Overview

The contemporary world is very dynamic and unstable. Profound changes and systemic turmoil, financial crises, migration, climate change, and international conflicts overlap and/or follow each other in quick succession, making the course of individual and social life largely unpredictable, hard to understand, unsafe, and threatening for many people—in a word: uncertain. This scenario, over the last two decades, has fostered the interest of psychology in uncertainty and socio-cognitive responses to it.

This paper presents a novel psychological model of the socio-cognitive management of uncertainty, the semiotic dimensional model (SDM). The SDM core claim is that uncertainty increases the momentum of affect-laden meanings in meaning-making. This is so

because affective meanings provide a simplified interpretation of the world that restores the experience of being able to make sense of the reality destabilized by uncertainty.

At the basis of the SDM there is the semiotic view of affects developed by the affective pertinentisation model (Salvatore et al. 2022), in turn, framed within the semiotic cultural psychology theory (Cremaschi et al. 2021; Salvatore 2016; and Valsiner 2007). This theoretical framework conceives of affects as meanings—namely, basic, hypergeneralized, abstract categories consisting of states of the body (e.g., positive vs. negative, active vs. calm) shaping the lived, holistic interpretations of the world (Salvatore and Freda 2011).

Affective meanings produce simplified interpretations of the world. There are two complementary reasons for this. On the one hand, affective meanings provide a homogenous and global view of the reality—they treat the context of experience as a whole, a single global entity (Salvatore and Zittoun 2011). On the other hand, the interpretation prompted by affective meanings is highly abstract—namely, it provides a representation of the world that radically reduces the complexity of the reality by focusing on just a few qualities (if not only one). These qualities consist of the basic states of the body making up the affective categories. For instance, the affect-laden interpretation of the world in terms of the foe/friend affective schema (Mannarini and Salvatore 2020; Salvatore et al. 2019d) radically simplifies the meaning-maker's task: the only aspect that matters is if the piece of the world to be interpreted (e.g., migrants, Arabs, or European institutions) is pro or against—with all other facets backgrounded.

The two-fold simplification produced by affective meanings explains why such meanings are activated to manage uncertainty: indeed, the more the homogeneity/abstraction of meaning, the less sensitive the meaning-making to the complexity of the reality that generates the uncertainty. Thus, by activating affective meanings, the meaning-maker reduces the magnitude of the uncertainty, thereby preserving its capacity to make sense of the experience. For instance, as long as the interpretation of the reality consists of viewing it as positive or negative, the uncertainty is radically reduced, because no other facet of it has to be considered.

The SDM provides a geometrical conceptualization of the role of affective meanings in the management of uncertainty. It is based on the idea that any product of meaning-making (e.g., an interpretation, a belief, a representation, or a statement about something) can be represented geometrically in terms of the dimensions of meaning that constitute it—where each dimension maps a given quality/aspect of the reality (Salvatore et al. 2022). In brief, dimensionality is a geometrical model of the complexity of meaning-making: the higher the dimensionality of an interpretation, the more the facets of the reality considered by the meaning-making (Kleinbub and Salvatore 2023). On the other hand, the lower the dimensionality, the more simplified the interpretation—namely the fewer the aspects of the reality it considers. Thus, for instance, a sommelier makes a high-dimensional judgment of a wine because she/he takes many components into account (see below, Section 2.2).

It follows that the simplified interpretations produced by affective meanings can be modelled geometrically as low-dimensional modes of making sense of the world—i.e., a map of the world characterized by the basic forms of body activation triggered by the encounter with the reality. This helps in understanding why affective simplification is a buffer against uncertainty—the higher the momentum of the affective meanings in the meaning-making, the lower the dimensionality of the latter, therefore, the smaller the source of variability the meaning-maker has to consider. In the final analysis, the fact that affective meanings reduce the dimensionality makes the meaning-maker blind to the complexity of the reality, focused on just the few basic aspects mapped by affects. Increasing the momentum of affective meanings is similar to reducing a camera's aperture to reduce overexposure to light.

In what follows, after a brief overview of the literature on uncertainty, the SDM framework is presented; then, the design and findings of its first empirical validation are presented and discussed.

1.2. The Psychological Response to Uncertainty: A Brief Review

Despite the many differences among models—beginning with what precisely is meant by uncertainty (see below, Section 2.1)—studies on the socio-cognitive response to uncertainty have led to two important points of agreement. First, many theories—those generally collected under the label of *threat management literature*—converge in considering the causal relation between uncertainty and response as being mediated by aversive arousal. According to this view, the response serves to cope with anxiety (e.g., Marigold et al. 2010) or, at any rate, the negative neuro-physiological activation (e.g., Greenberg and Arndt 2011; Proulx and Inzlicht 2012; and van den Bos 2009) triggered by the destabilization caused by uncertainty (rather than with the destabilization in itself). Second, there is wide—though not unanimous (e.g., Major et al. 2007)—recognition of the plurality of the responses as well as the fact that they are not necessarily related to the source of the uncertainty. Incidentally, the two previous points are connected. Indeed, insofar as the response is a way to cope with aversive arousal, its characteristics have to fit with this function, regardless of its consistency with the source of uncertainty.

Both ideas (the mediational role of aversive arousal and the plurality/unrelatedness of responses) were already present in terror management theory (Greenberg and Arndt 2011), which, though strictly speaking cannot be considered a theory of uncertainty, represents the starting point and is still a point of reference in this domain of studies (van den Bos 2009). According to terror management theory, the awareness of being mortal, when experienced, raises deep anxiety. The individual copes with this anxiety by means of a plurality of strategies—e.g., adherence to polarized ideologies or religious credos, identification with the in-group, or search for a scapegoat—which are unrelated to death salience. What these strategies have in common is their function as ways of affirming the sense of continuity beyond death, e.g., as members of the community. The meaning maintenance model (Proulx and Inzlicht 2012) generalizes the terror management theory view. It states that uncertainty consists of the failure of the personal meaning (rather than of death salience alone), defined as the capacity to establish stable connections between environmental occurrences. The failure triggers an aversive neurophysiological arousal, which pushes the meaning-maker to activate other meanings that, insofar as they work, restore his/her sense of meaning stability. In doing so, the aversive neuropsychological arousal is overcome. Thus, as authors underline, the response is palliative—the new meaning is not aimed at solving the failure of the destabilized meaning; rather, it provides an illusory, compensative experience in order to quell the aversive arousal. Partially similar, the uncertainty management model (van den Bos 2009) and the uncertainty–identity theory (Hogg 2007) state that people cope with the aversive arousal triggered by self-uncertainty—i.e., the feeling of being uncertain as to who one is—by, respectively, adhering to cultural worldviews and ideologies, and identifying with high entitativity groups. Of note, the unrelatedness of the responses has been recently endorsed by authors who consider the control reduction and the related disruption of the capacity to act (rather than aversive arousal) to be the mediators between uncertainty and response. This is so in the case of Landau and colleagues (2015), who, within the compensatory control theory framework, have shown that people can compensate for their reduced control to include non-specific responses, consisting of "interpretations of the environment that are superficially unrelated to the control-reducing condition" (Figure 1, p. 3).

The recognition of the plurality of responses to uncertainty and the unrelatedness of most of them to the source provide a unifying frame to understand the common psychosocial root of many phenomena characterizing the current socio-institutional scenario (Salvatore et al. 2019d, 2021a): e.g., ideological polarization, religious radicalization, conspiracy theories, and identification with the in-group (e.g., Hogg et al. 2007; Greenberg and Arndt 2011; for a general discussion, see Landau et al. 2015). Above all, such a frame enables us to address the puzzling fact that many of the current socio-institutional phenomena prove to be reactions that do not empower but often weaken people's capacity to cope with the concerns motivating them. For instance, it is widely recognized that

the preference for far-right and/or populist forces is not associated with the capacity of these political programs to provide successful solutions to the socio-economic crisis, but to the fact that they can provide reassurance amidst the anxiety aroused by the crisis (e.g., Elchardus and Spruyt 2016; Russell Hochschild 2016; see also Russo et al. 2020). This can be understood in light of the fact that responses are buffers against the aversive arousal caused by uncertainty, rather than socio-cognitive resources aimed at addressing the sources of uncertainty (Cremaschi et al. 2021).

However, the plurality and unrelatedness of responses to the source of uncertainty make it even more pressing to ask *how* these responses are built and *how* they mitigate uncertainty—what cognitive processes underlie the construction of the meaning-maker's response as well as its efficacy?

Most of the current uncertainty literature provides a functionalist, output-centered answer to this question. To put it briefly, the starting point is the empirical evidence showing that an increase in uncertainty (or assumed equivalent conditions) produces a given set of responses as output. Theories then explain this causal linkage by crediting the response with the functional properties that make it the solution of the state of uncertainty. Take, for instance, the terror management theory (Greenberg and Arndt 2011). Given that people respond to death anxiety by adhering to polarized beliefs, then the latter are considered a buffer against such anxiety. The explanation of why and how this is so is found in the property of the polarized beliefs that enables them to work as a buffer—i.e., their capacity to project the self beyond death. Again, consider the compensatory control theory postulation that people are motivated to keep a sense of control over their world and, therefore, are prone to adopt certain strategies when such a sense is weakened—e.g., to empower their belief in a controlling God, to affirm structured interpretations of the world, or to endorse the government. These strategies are considered to be successful because they magnify the trait that enables them to offer protection against the lack of control—e.g., the sense that there is, however, something that can keep the world under control.

It has to be recognized that this functionalist, output-centred approach is unable to build a complete explanatory model of the mechanisms underlying the meaning-making of uncertainty. This is regardless of the theories' heuristic validity; rather, such a limit is inherent to the approach because it focuses on what responses uncertainty triggers and why—i.e., due to what characteristics they work, rather than on how this happens. Therefore, it is worth enhancing the functionalist approach with a computational, process-centred focus, aimed at a fine-grained modelling of the meaning-making process underlying the capacity of the socio-cognitive responses to manage uncertainty.

This purpose is relevant for both theoretical and practical reasons. From a theoretical standpoint, the response to uncertainty can provide a meta-framework to integrate the different socio-cognitive models of uncertainty proposed so far (De Luca Picione and Lozzi 2021). From a practical standpoint, a fine-grained understanding of the cognitive processes underlying how people make sense of uncertainty can help to identify and promote forms of meaning-making and socio-cognitive strategies that empower individual and collective wellbeing.

To the best of our knowledge, this task has been addressed from a neuroscientific perspective with studies that have highlighted the neurobiological circuits and processes involved in the processing of the anxiety induced by uncertainty (e.g., Grupe and Nitschke 2013; McGregor et al. 2010; but see Hirsh et al. 2012, for a formalized psychological model).

The semiotic dimensionality model (SDM) of the meaning-making of uncertainty aims at helping to explain this process from a psychological and computational standpoint, namely, in terms of the fine-grained processes though which the meaning-maker interprets the condition of uncertainty. The next section provides an outline of the model and of the theoretical framework on which it is grounded.

2. The Semiotic Dimensionality Model (SDM)

2.1. The Definition of Uncertainty

First of all, let us clarify what the SDM means by uncertainty. The SDM defines uncertainty as the failure of the domain meaning that frames the meaning-maker's interpretation of events/objects. Of note, according to the SDM, the meaning that fails is not the one involved in the interpretation of discrete objects, events, and goals (*object-specific* meaning); rather, the SDM postulates that uncertainty concerns the failure of the *domain* meaning—namely, the *super-ordered meaning providing the interpretation of the whole environment which frames the cognitive processing of objects and events*. This super-ordered meaning has been modelled by dozens of psychological theories—e.g., mental models (Johnson-Laird 1983), social representations (Moscovici 1961, 1976), schemata (Neisser 1987), scripts (Schank and Abelson 1977)—more recently: symbolic universes (Salvatore et al. 2019b), and field signs (Valsiner 2007). According to the SDM, the domain meaning reduces the complexity of the environment (Peterson and Flanders 2002); in doing so, the domain meaning brings certain aspects of the environment to the fore, backgrounding others; this makes stable objects emerge, which, in turn, can be interpreted by the meaning-maker (Salvatore 2016). Consider, for example, a person who finds on the path a long, narrow piece of wood. In itself, it has no fixed meaning because it could be interpreted in almost infinite ways, therefore, becoming almost infinite objects. The person has to reduce these infinite interpretative possibilities in order to "extract" a stable object from them. They do so by means of the domain meaning that provides the interpretative framework that brings to the fore certain facets of the context where the piece of wood is experienced while pushing others into the background. Thus, say the person is enjoying a pleasant walk in the mountains—probably the domain meaning they embrace at that moment is the one that shapes the context as pleasant and full of nice things to enjoy. The piece of wood will be interpreted in terms of these qualities—e.g., as a beautiful natural form, or as a useful walking stick. Image now, the same person in a jungle, interpreted as a dangerous context. Most probably, what they would see in the piece of wood is one or more qualities which are consistent with the domain meaning of danger—e.g., initially, they might perceive it as a snake and then bring to the fore its affordances to be used as a weapon. In brief, the meaning of the stick is in each situation the selective result of the interpretation of the context produced by the domain meaning and framing the meaning-maker's mode of making sense of the object.

Now, in certain circumstances of major, unexpected variation of environmental complexity, the currently established domain meaning may fail to fulfil its task. As a result, the meaning-maker becomes unable to process the experience—the capacity of making sense of objects and events is destabilized (Peterson 1999; for a model of the decay of the interpretative capacity of domain meanings, see Salvatore et al. 2021b).

In sum, according to the SDM, uncertainty: (a) consists of the destabilization/decay of efficacy of the current meaning-making, (b) which is due to the failure of the domain meaning operating as interpretative framework, (c) in turn induced by an unexpected increase in environmental complexity.

At the computational level, the SMD conceptualizes domain meaning in accordance with the view of cognition in terms of Bayesian inference (Barsalou 2011). More particularly, following this view, the interpretation of the context consists of the on-going Bayesian forecast of the instant-by-instant evolution of the perceptual field. In other words, the interpretation is not the representation of what the stimulus is but the fit between what the stimulus is going to be and what it is in the following instant. The interpretation of the reality, already at the level of perception, is a form of anticipation. For example, the hunter does not shoot at the bird in flight at the point where he took aim at time t_1 (in the past); rather, he shoots toward the point where he expects the prey will be at time t_2, that is, when the bullet will reach it.

Now, the forecast is based on the knowledge of the possible evolution of the environment—this is where the Bayesian nature of the inference lies. The hunter bases the forecast on an implicit knowledge of the shape of the bird's trajectory—in the Bayesian

inference, that is the prior distribution probability. Following this view, the interpreter's domain meaning can be modelled as the Bayesian prior vector, providing the conditional contextual interpretation framing such a forecast (Salvatore et al. 2021b).

Accordingly, at the computational level of analysis, the state of uncertainty can be modelled as a major misfit of the forecast concerning the on-going evolution of the context. Such a misfit stimulates the body's arousal, calling for perceptual and motor regulation to restore the capacity of fit and, in parallel, to rewrite the Bayesian prior vector (for a similar view, framed within the entropy model, see Hirsh et al. 2012).

In brief, uncertainty is the local (i.e., occurring in the current moment) inability of the on-going interpretation of the context to satisfy the demand for grounding the understanding and forecasting of events and objects efficaciously.

2.2. The Model of the Domain Meaning

The SDM conceptualizes domain meaning in accordance with the affective pertinentisation model (APER; Salvatore 2016; Salvatore et al. 2022). Integrating semiotic cultural psychology, psychoanalytic theory of affects and embodied cognition, the APER moves from the largely accepted principle that cognitive processes are framed within the interpretation of the contextual situation, which grounds the use of cognitive resources (e.g., schemata, narratives, concepts, pockets of knowledge, and heuristics) (see above, Section 2.1). On this basis, the APER makes the following core claims.

(1) First, the APER models domain meaning in terms of mental phase space (MPS). Each dimension of the MPS detects a property/quality of the contextual situation. If you like, the cognitive system carries out a sort of factorial analysis by means of which it detects the contextual situation by breaking it down into a set of basic qualities/properties. Accordingly, the higher the MPS dimensionality, the higher the number of facets of the contextual situation that the cognitive elaboration—i.e., the Bayesian forecast (see above, Section 2.1)—takes into account;

(2) Second, the APER adopts the semiotic view of affects, namely, the idea that affects are basic, generalized, and bi-polar embodied meanings (on the view of affects as basic meanings, see Barrett 2006; Murphy and Zajonc 1993; Osgood et al. 1957; from a psychoanalytic standpoint, Fornari 1979; Klein 1967; Matte Blanco 1975; Salvatore and Freda 2011; Stein 1991; on the bi-polar structure of affects, see Barrett and Russell 1998). Each affective dimension of meaning consists of a form of interpretation of the experience in terms of a global pattern of bodily activation (e.g., pleasure/unpleasure). Based on the semiotic view of affects, the APER claims that the affective meanings work as the core dimensions of the MPS—affects are the first modes of making sense of experience that the individual learns from birth; through ontogenesis, the individual learns further, more cognitively advanced, abstract classes of meaning, which contribute to the dimensionality of the MPS (for instance, abstract concepts such as freedom, utility, and openness; on the linkages between affective and abstract concepts, see Borghi et al. 2017);

(3) Third, the MPS has variable dimensionality, both within and between individuals. The within-individual variability is due to the complexity of the cognitive task—the greater the complexity, the more the meaning-maker needs to take components of contextual variability into account, therefore, the greater the demand for dimensionality. Accordingly, the between-individual variability can be conceived as the precipitate of the demands for dimensionality the meaning-makers have had to deal with throughout their lives.

2.3. The Regulation of Uncertainty

Framed on the APER, the SDM claims that the *meaning-maker regulates uncertainty by reducing the dimensionality of the MPS*. This is so because the lower the dimensionality, the fewer the components of contextual variability to be managed, therefore, the higher the chance of the forecast's success. Accordingly, when the contextual situation proves

to convey high variability/complexity—therefore, uncertainty—the meaning-maker may cope with it by decreasing the MPS dimensionality. In doing so, a considerable amount of variability is backgrounded, and the forecast's capacity for success, therefore, the stability of the system of meaning, is protected/restored. Figure 1 provides a visual illustration of such a process.

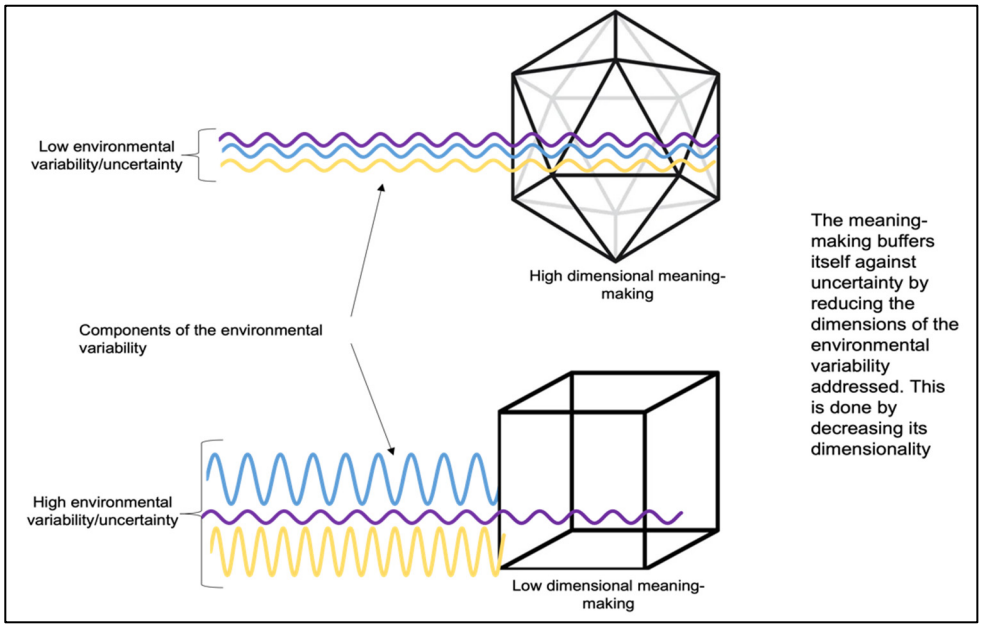

Figure 1. The regulation of uncertainty process of the SDM.

To use an analogy, a low-dimension MPS operates similar to a roulette player who, in order to reduce the risk of failure, makes a one-dimensional bet—e.g., the color, red vs. black. In doing so, the other sources of potential contextual variability are backgrounded, therefore, constraints on the forecast decrease and, conversely, the chance of winning increases. A more risk-oriented player could bet on a combination of output (e.g., pair/red/numbers from 1 to 18); this means that more dimensions of variability are introduced, and, with them, more degrees of freedom, thus, more constraints over the forecast—in the final analysis, more chances of failure (therefore, the more the win is worth).

It is worth highlighting that the lower the MPS dimensionality, the higher the contribution of affective meanings to meaning-making (Kleinbub et al. 2021). Indeed, as observed above, these dimensions are basic MPS components, whose role increases in proportion to the backgrounding of the more cognitively advanced dimensions.

Accordingly, a low-dimension MPS provides a polarized, affect-laden, hypergeneralized, homogenizing interpretation of the contextual situation that backgrounds most nuances and details, and makes sense of it in terms of a few dichotomic alternatives. This modality is evident in several polarized, affect-laden narratives in terms of which large segments of population interpret the social world—e.g., the populist view of the conflict between the elite and the people as an all-comprehensive, good-for-all interpretative framework of social and political scenarios (e.g., Kriesi and Pappas 2015); the anti-immigration discourses that picture migrants as the fundamental threat for Western society (e.g., Mazzara et al. 2021); or the conspiracy theories that interpret any social event as a manipulation carried out by powerful hidden agents (Marcus 1999). These narratives are affect-laden in the sense that they are subjectively relevant modes of engaging with the reality, fostering individual and collective identities (Cremaschi et al. 2021); moreover, they are polarized in the sense that they consist of the attribution of extreme values, which makes the interpretation based on them blind to nuances and differences.

2.4. Preliminary Evidence in Support of the SDM

Findings of some studies are consistent with the idea underlying the SDM that meaning-making can be modelled in terms of dimensionality and that affect-laden, simplified meanings are characterized by low dimensionality.

Tonti and Salvatore (2015) found that behavioral and textual indexes of the activation of affective meanings are related to several measures of the dimensionality of the representation of social objects (e.g., immigrants, future) and of the way to perform an evaluation task. In their analysis of a set of samples of European populations, Salvatore and colleagues (2019b) found five generalized worldviews (symbolic universes, in the terminology adopted) that are active within such societies. These symbolic universes proved to be characterized by different dimensionality and further analyses highlighted that people associated with the lower-dimension symbolic universes showed: (a) more polarized attitude towards foreigners; (b) more need for closure; and (c) higher scores on the extroversion personality trait (Salvatore et al. 2019c) than people associated with higher-dimension symbolic universes. Moreover, people characterized by lower-dimension symbolic universes proved to have a narrower attentional distribution when asked to watch an image than people with higher-dimension symbolic universes, who proved to be more inclined to explore the marginal component of the stimulus (Salvatore et al. 2019a).

Recently, Gennaro et al. (2021) have developed a measure of the dimensionality of textual meaning (affective saturation index; ASI). More particularly, the ASI adopts a computer-assisted procedure of textual analysis aimed at breaking down the semantic content of a given textual corpus (e.g., a set of interviews) into its components of meaning. On this basis, the ASI measures how relevant are the first components of meaning compared to the others. Thus, the higher the ASI, the lower the dimensionality of the textual meaning. Consistently with the APER hypothesis of the affective nature of the first components of meaning, the authors found that the ASI was highly related with a physiological index of affective activation (based on heart-rate variability). Thus, the study provides evidence supporting the conclusion that the characterization of affective meaning in terms of low dimensionality is also valid at the level of textual meaning.

From a different standpoint, the dimensionality of the mental phase space has been used to frame a unified model of psychopathology (Venuleo et al. 2020), which received its first empirical validation in a study based on neural networks simulating psychopathological and non-psychopathological cognitive process (Kleinbub et al. 2021). The network simulating pathological cognitive processes showed computational dynamics that proved to have a lower dimensionality than the non-pathological control networks. Accordingly, insofar as psychopathology is assumed to involve a form of cognition highly influenced by the affects, it can be concluded that this study provides indirect support to the SDM view of affects in terms of dimensionality.

Finally, Salvatore et al. (2020) compared the findings of a set of analyses aimed at detecting how six social objects—Islam, immigration, homosexuality, health, democracy, and subjectivity—were represented in a sample of 69 newspapers in six European countries (Cyprus, Italy, Greece, Malta, Romania, and the UK) over a period of about two decades. Each object was analysed separately in each country. For each object, independent blind raters measured the degree of alterity implied in it. In parallel, always for each object, the similarity among the representations detected in each European country was estimated. Alterity and similarity proved to be fully associated—e.g., Islam and immigration, characterized by the highest level of alterity, were represented in almost the same way over the countries; the representation of democracy and subjectivity, characterized by the lowest level of alterity, were the most dissimilar among countries. This finding can be viewed as indirect support for the SDM model because the similarity of the representation can be interpreted as indicative of a low-dimension MPS. Indeed, as discussed above, a low-dimension MPS is focused on the basic affective components, which are the same across the socio-cultural contexts investigated. Accordingly, insofar as the exposure to alterity is considered a trigger of anxiety, therefore, of affective arousal, these findings are

consistent with the SDM idea that the greater the uncertainty, the lower the dimensionality of representation, therefore, the more similar the representations among countries.

As to the relation between dimensionality and uncertainty, it is worth mentioning the findings of a recent study. Cordella et al. (2023) modeled the psycho-social determinants of COVID-19 vaccine hesitancy in a representative sample of the Italian population. Among other findings, they showed that vaccine hesitancy was influenced by trust in institutions and that this effect was moderated by affect-laden worldviews (e.g., symbolic universes, see above). Moreover, they found that the moderation effect of the symbolic universes depended on the level of uncertainty to which subjects were exposed (measured in terms of the level of economic resources available to protect them from the impacts of the pandemic). Thus, this study suggests that the greater the uncertainty experienced, the more the affect-laden meanings gain momentum in people's meaning-making and related behavior.

Aims and Hypotheses

Since the studies reported above provide only indirect support to the SDM, the aim of this paper is to report the first direct empirical validation of the SDM. The two SDM core tenets were tested by means of the following design.

First (HP1), the SDM assumption that the low-dimensional mental phase space is the computational descriptor of the affective meaning was tested. Accordingly, it was hypothesized that there is an inverse relation between the affect-laden beliefs and the dimensionality of the meaning-maker's mental phase space. More particularly, three measures of beliefs ((*positive*) *attitude towards foreigners*, *ethnic identity*, *and punitive attitude*, see below, *Method* section)) that in their polarized level can be considered forms of affective meanings were selected and it was expected that they would have an inverse association with an independent measure of the dimensionality of participants' mental phase space.

Second, an experimental study was designed in which uncertainty was manipulated so as to assess its effects on the dimensionality of participants' mental phase space. As will be detailed below, the uncertainty was manipulated by an ad hoc experimental paradigm. In a nutshell, the paradigm was aimed at inducing a condition of uncertainty by making a subjectively relevant domain meaning (the national identity frame) break down, after having activated it covertly. It was hypothesized (HP2) that uncertainty so produced induces a decrease in the mental phase space dimensionality. Accordingly, it was expected that, ceteris paribus, the mental phase space of the experimental group's participants would have lower dimensionality than that of participants in the control condition.

3. Materials and Methods

3.1. Design

Hypothesis 1 was tested by means of a series of regression models aimed at estimating the role played by dimensionality to explain polarized, affect-laden meanings. To this end, three measures were selected as dependent: (*positive) attitude towards foreigners*, *ethnic identity*, and *punitive attitude* (see below)—since they express beliefs strongly influenced by affectivized forms of meaning-making. As to *attitude towards foreigners* and *ethnic identity*, there is broad agreement that they reflect the salience of identity motives (e.g., Brown 2000), in turn, seen as reflecting emotional, affect-laden beliefs (Cremaschi et al. 2021). Similarly, *punitive attitude* proved to be associated with manifestations of polarized and affect-laden mindsets—attributive simplicity (Fletcher et al. 1986) and authoritarianism (McKee and Feather 2008).

The experimental paradigm designed to test Hypothesis 2 worked as follows: after having primed participants' national identity (i.e., the sense of being Italian) they were asked to provide an evaluation of an event triggering national identity-related feelings and attitudes; then, they were assigned to two different conditions: in one (control) they were told that a sample of Italians agreed with them, in the other (experimental) that they did not. We inserted the second condition assuming that the disagreement with the in-group would lead to an increase in uncertainty, as result of the breaking down of the national frame.

Effects were estimated by means of indexes of the dimensionality of the meaning and of its affect-laden quality.

In what follows, the three-stage logical architecture of the design is briefly outlined (details in Section 3.3; see also Figure 1; materials used in the study are described in the Supplementary Material).

Stage 1. The national identity was primed (as the sample was composed of Italian people, we made Italian identity frame salient). For this purpose, (a) the study was presented as aimed at collecting the thoughts of participants, as Italians, about issues concerning Italy; moreover, (b) participants were asked to describe to what extent some well-known unique, highly valued aspects of Italy—e.g., Italian art, food, and landscape—were associated with a set of feelings.

Stage 2. A failure in the expectations based on national identity was induced. First of all, participants were asked to read a text, that is, a newspaper article reporting a recent terrorist act, and to record their attitudes towards the aggressor. After that, participants received feedback on the whole sample's average attitude towards the aggressor. While the episode was real (taken from an Italian newspaper at the time of the study), the feedback provided to participants was fictional (accordingly, henceforth we refer to it as *fictional feedback*). In the experimental condition, the fictional feedback was highly dissonant with the participant's evaluation (henceforth, DISSONANT condition), while it was highly consonant in the control condition (henceforth, CONSONANT condition). This manipulation was considered a way to induce the breakdown of the national identity frame—therefore, to trigger uncertainty. More particularly, according to the rationale of the design, the breakdown concerns the implicit expectation—working as domain meaning—that in-group members have the same view of relevant, identity-related issues (for a consistent theoretical perspective, see Swann et al. 2012). Accordingly, the design assumes that the salience of national identity would ground the participant's forecast that in-group members would agree with their response. Accordingly, the exposure to a highly dissonant in-group output proves this forecast inaccurate, therefore, destabilizing the national identity frame.

Besides the main manipulation, the design adopted a further control, used to test whether the effect of the main manipulation (i.e., the DISSONANT condition) was specifically due to the breakdown of the Italian national identity frame. Half the participants were told that the (fictional) sample to which their response was compared was Italian (IN-GROUP condition), while the other half were told that it was extra-EU foreigners living in Italy (OUT-GROUP condition). According to the rationale of the design, participants of the OUT-GROUP condition were prevented from basing the forecast of the fictional feedback on the Italian identity national frame; consequently, if the experimental effect proved to be present in the IN-GROUP but not in the OUT-GROUP condition, this would provide counterfactual evidence that the effect of the DISSONANT condition is due to the Italian national identity frame.

Stage 3. Measurement of effects. Experimental and control groups were compared on measures of affective meanings and dimensionality of the mental phase space (the same measures used for the HP1 test).

3.2. Participants

The sample comprised 120 participants (mean age: 36.21; SD = 14.78) recruited by means of a snowball procedure. The sample size was determined to detect a medium effect size (0.35) with 90% power. No exclusion criterion was adopted. All participants were of Italian nationality and mother tongue. The sample was balanced on gender: 60 women (mean age: 33.31, SD = 14.02) and 60 men (mean age: 39.11, SD = 15.05); 8.3% of the sample had a primary level of education; 45.8% low–medium level education; 40% high–medium level education, and 5.8% university degree. 63.7% of the sample declared their economic status was on the average of the Italian population, 14.2% lower than the average, 22.5% higher.

Participants were assigned to the four conditions of the study (DISSONANT/CONSONANT/OUT-GROUP/IN-GROUP) randomly.

3.3. Procedure and Materials

Each participant carried out the tasks of the study individually, in a single session. Stimuli and responses were presented by means of an ad hoc software system, created with a PHP script embedded in the webpage http://www.eicap.eu/DAI/, 28 December 2022, implemented on a fixed computer with a good internet connection, in a quiet room without any disturbance.

Figure 2 shows the flow of tasks implemented by the study. It comprises the following steps grouped in three stages.

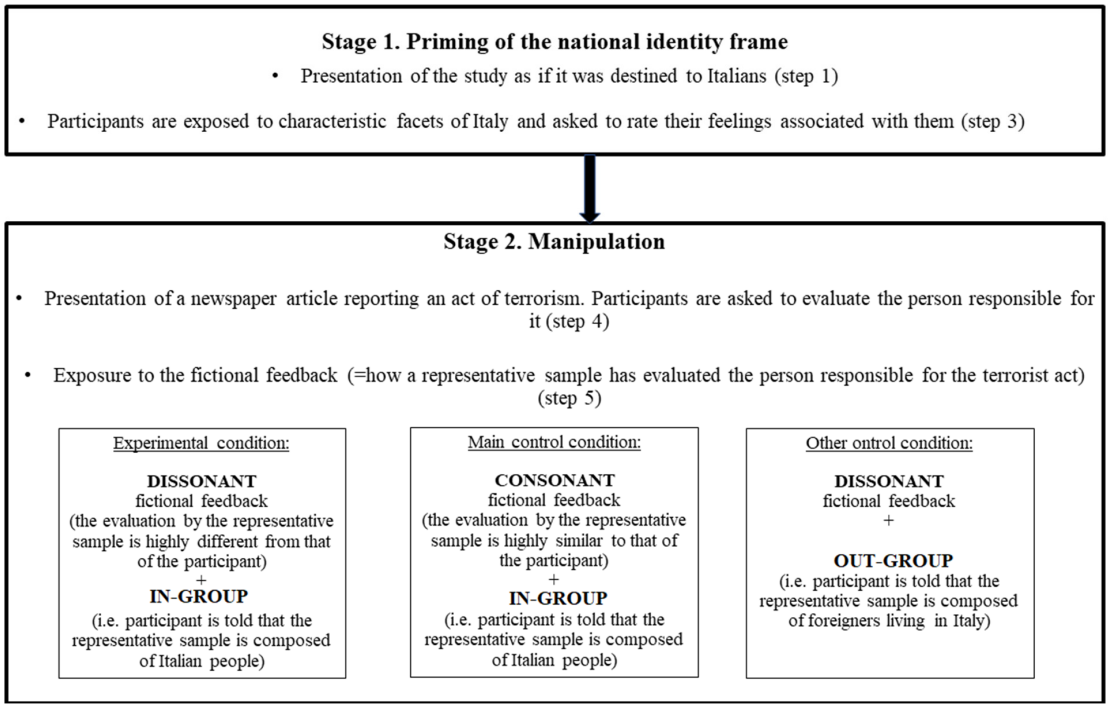

Figure 2. Architecture of the experimental paradigm.

3.3.1. STAGE 1: Priming of the National Identity Frame

(Step 1) Presentation of the study. The description of the purpose of the study was fictional, aimed at the initial priming of the national identity frame. Moreover, to reinforce the national identity frame, participants were told that the study was commissioned by a foreign institution; also, the contact email of the research staff (che_cosa_gli_Italiani_pensano@gmail.com (what_italians_think@gmail.com)) conveyed the idea that participants were recruited because of their being Italian. The English translation of the presentation is reported in supplementary materials (Supplementary Material, SM1, Box S1).

(Step 2) Preliminary socio-demographic and psycho-social measurement. Socio-demographic form, semantic differential on facets concerning identity-related objects, prejudice scale, identity scale, and a personality traits measure (TIPI) were applied.

(Step 3) Presentation of characteristic facets of Italy and evaluation of feelings associated with them. Participants were exposed to images, accompanied by a descriptive label (cf. Supplementary Material, SM1, Box S2), representing five characteristic facets of Italy: Italian arts (Michelangelo and Botticelli paintings), Italian cuisine (cheese and wine), Italian cities (Venice and Rome), Italian landscapes (seaside and alps), and Italian anthem (auditory stimulus). In order to foster the participant's involvement, after each facet, the participant was asked to evaluate how the facet was associated with each of five feelings—pride, belongingness, responsibility, pleasure, and power.

3.3.2. STAGE 2: Manipulation of Uncertainty

(Step 4) Presentation of the text reporting the episode of terrorism and evaluation of the person responsible for it. After reading a 30-word text describing a terrorist act (Supplementary Material, SM1, Box S3), the participant had to score her/his evaluation of the person responsible for the act on four Likert-like scales (see Measures).

(Step 5) Exposure to the fictional feedback. The fictional feedback was presented to the participant by means of a graph showing the synthetic comparison between the participant's evaluation of the act and that provided by the (fictional) sample (see Supplementary Material, SM1, Box S4). The DISSONANT condition was induced by exposing the participant to a graph showing that 2.22% of the sample had expressed the same or a similar opinion as her/him, 8.11% a rather different opinion, and 89.67% an extremely different evaluation. In the CONSONANT condition, the distribution of the percentage was inverted, with 89.67%, 8.11%, and 2.22% for same/similar, rather different, and extremely different evaluation, respectively. IN-GROUP and OUT-GROUP conditions were differentiated by specifying that the sample was composed of Italians living in the country (IN-GROUP condition) or extra-EU foreigners living in the country (OUT-GROUP condition) (cf. Supplementary Material, SM1, Box S4).

(Step 6) Manipulation check. Participants were asked to evaluate the fictional feedback on a Likert scale applied to a set of items aimed at estimating the credibility of the feedback. These responses were used as the manipulation check (cf. Supplementary Material, SM1, Box S5).

3.3.3. STAGE 3: Measurement of Experimental Effects

(Step 7) Measures of the effect of the manipulation on the dependent variables (e.g., polarization and dimensionality) were applied (see Measures).

(Step 8) Final debriefing. Given that the presentation of the study required a partially false belief to be induced in participants, at the end of the task, the staff member provided them with the correct information about the study. After that, the participant was asked to confirm the informed consent provided at the beginning of the procedure (cf. Supplementary material, SM1, Box S6).

The whole protocol took about 40′ on average to be carried out.

3.4. Measures

Preliminary measures (Step 2)

Socio-demographic form. The form gathered information as to gender, age, education, and self-description of income level.

Feelings about aspects of Italy. Participants were asked to evaluate the feeling raised by five characteristic facets of Italy: Italian arts (Michelangelo and Botticelli paintings), Italian cuisine (cheese and wine), Italian cities (Venice and Rome), Italian landscapes (seaside and alps), and Italian anthem (auditory stimulus) (see Section 3.3., step 3). Five feelings for each characteristic were evaluated—pride, belongingness, responsibility, pleasure, and power—each of them on a four-point Likert-type scale (not at all, little, quite, and very). Given that this task had the sole purpose of conveying the priming effect, these measures will not be described in detail.

Within-individual semantic differential dimensionality (WISDD). WISDD is an index of dimensionality, built on the responses to a battery of semantic differentials. The battery was composed of 10 seven-point bipolar Likert scales—*bad–good*; *strong–weak*; *fast–slow*; *pleasant–unpleasant*; *big–small*; *hot–cold*; *beautiful–ugly*; *heavy–light*; *switched on–switched off*; and *harmless–dangerous* (English translations from the original in Italian), each of them applied to four target objects: "*Italy*", "*Foreigners*", "*Immigrants*", and "*Islamic fundamentalism*". Content and structure of bipolar scales were defined in accordance with the mainstream applications of this technique (Osgood et al. 1957, 1975). The four objects were chosen due to their capacity for both helping to prime the in-group/out-group differentiation and triggering an emotional modality of evaluation.

Responses to the semantic differentials were used to build the WISDD. To this end, the responses were subjected to a within-individual analysis aimed at estimating the dimensionality of the MPS underlying the participant's responses to the semantic differential. More particularly, each participant's 10 scales/4 objects response matrix was factorialized (PCA, no rotation). Thus, 120 PCA were performed, one for each participant. For each participant's PCA output, the WISDD was calculated as the *cumulative variance explained by the first two factors*. Consistently with the approach developed by Kleinbub and colleagues (2021) and Gennaro et al. (2021), WISDD can be viewed as an (inverse) index of dimensionality. Indeed, the higher the variance explained by the first two dimensions, the lower the variance explained by the last two dimensions (given that the matrix had four columns and each PCA extracted four components). Thus, to be precise, the WISDD measures the dimensionality in terms of the relevance of the first two dimensions of the PMS (rather than in terms of the number of dimensions in itself).

WISDD was used both as independent variable in the analysis aimed at testing Hypothesis 1 and to control participants' baseline dimensionality in the analysis aimed at testing Hypothesis 2.

The national identity scale (Lewin-Epstein and Levanon 2005) is an eight-item scale measuring two factors: civic identity (Items 2–3–6–7) and ethnic identity (Items 1–4–5–8). Respondents are invited to evaluate to what extent certain aspects are important for being Italian, on four-point Likert-type scales from 1 (absolutely irrelevant) to (4 absolutely relevant). The aspects proposed are: having citizenship, living there for a large part of one's life, speaking the language, obeying local law and its enforcement institutions (civic identity, Cronbach's alfa = 0.394), being born in the country, being of a majority local religion, feeling Italian, and having Italian ancestors (ethnic identity; Cronbach's alfa = 0.631). The following analyses adopted only the score of ethnic identity subscale.

Positive attitudes towards foreigners, measured by means of the prejudice scale (PS, Costarelli 2011). The PS measures three components of the relationship with strangers: (a) perception; (b) attitude; and (c) feeling towards foreigners. Given the similarity of results among these three dimensions and based on the findings of previous analyses (Salvatore et al. 2019c), the current study used just four items of the original 32-item scale: (1) I would not find anything wrong in working for a foreigner; (2) If a foreigner should become my relative, this would not present a problem; (3) It would be better if foreigners avoided places where they are not welcome; and (4) Foreigners living in the place where I live transfer values to their children that are often in conflict with the ones of my community. Respondents were asked to express their level of agreement with each item on a four-point Likert-type scale (from 1, completely disagree, to 4, completely agree). Factorial analysis confirmed the mono-dimensionality (59.61% of variance explained) of the subscale. The factorial dimension is associated positively with items detecting a positive attitude towards foreigners (loading coefficients 0.875, and 0.885, for item 1 and 2, respectively) and negatively with the aversive item (loading coefficients −0.680 and −0.611, for item 3 and 4, respectively). Accordingly, we interpreted factorial scores as indicative of positive attitude towards foreigners.

Personality traits. We used the 10-item TIPI scale (Gosling et al. 2003) to assess the big five dimensions of personality. Each dimension corresponds to a subscale: extroversion (i.e., assertive, energetic, dominant, and sociable), agreeableness (i.e., cooperative, friendly, trustful, and generous), conscientiousness (i.e., responsible, orderly, and scrupulous), emotional stability (control of emotion, not neurotic, and not easily upset),and openness to experience (searching for novelty, originality, and creativity).

The following analyses used the agreeableness, conscientiousness, and openness to experience subscales.

Punitive attitude in the evaluation of the terrorist act (step 4). Participants were asked to evaluate the person responsible for the terrorist act on a five-point Likert-like scale of agreement (from 1 = not at all agree to 5 = fully agree), applied to four statements. Two statements concerned punitive attitude (e.g., "whoever is guilty of such crimes deserves no

mercy" (English translation from the Italian)); two statements expressed a compassionate, benevolent point of view towards the culprit (e.g., "Even in the face of the most horrible gestures, it is necessary to try to understand the point of view of those who perform them" (English translation from the Italian)).

The four items were factorialized (ACP, varimax rotation). A one-dimensional solution emerged (60.11% of variance explained). The dimension has a positive association with the agreement with the two punitive statements (loading coefficient: 0.819 and 0.881, respectively) and a negative association with the benevolent statements (loading coefficient: −0.723 and −0.659, respectively). Accordingly, the factor was labelled *punitive attitude* and used both as dependent variable (in analyses related to HP1) and control (in analyses related to HP2).

3.4.1. Manipulation Check (Step 6)

Evaluation of the fictional feedback. Participants were asked to evaluate four aspects of/feelings associated with the fictional sample's feedback. To this end, they were asked to respond to the following questions: (a) "What is your reaction to the sample's opinions we have just shown you?": "uncertainty" or "agreement"; (b) "In your view, to what extent are the sample's opinions we have just shown you?": "predictable" or "right". Each evaluation was performed on a seven-point Likert-like scale (1 = not at all, 7 = extremely). These scores were used in the manipulation check.

3.4.2. Post-Experimental Measure (Step 7)

The Lexical Meaning Dimensionality. Responses to a task of free association were used to build an index of the lexical meaning dimensionality (LMD). The LMD estimates the semantic spectrum of the words the participant produces in response to a task of free association.

To this end, participants were asked to write down all words that came to their mind when thinking about each of the following seven stimuli: immigrants, Islam, climate change, European Union, politicians, the President of the Italian Republic Sergio Mattarella, and the Pope.

One participants/lexemes matrix was obtained in this way. In other words, the matrix was built in order to have, for each participant/row, all lexemes written down for all stimuli. The lexeme is the super-ordered lexical category to which the word belongs (e.g., "went" belongs to the lexeme "to go"). Each *ij*-th cell of the matrix reports "1" if the *i*-th lexeme is present in the string of words of the *j*-th participant; "0" otherwise. To build the matrix, the 115 lexemes occurring at least nine times were selected. This was done in order to optimize the ratio between rows and columns and in order to avoid producing a too dispersive matrix (for a discussion of these technical details, see Salvatore et al. 2017).

Based on the same logic adopted for the computation of the affective saturation index (ASI) (Gennaro et al. 2021), the matrix was subjected to a multiple correspondence analysis (MCA). The MCA maps the distribution of lexemes by breaking it down into factorial dimensions, each of them detecting a pattern of lexemes that tend to co-occur within individuals. Accordingly, each factorial dimension can be viewed as a computational description of a component of meaning, underpinning a "slice" of the whole lexical variability of the matrix (Rochira et al. 2020).

Similarly to WISDD, the LMD was computed as the contribution of the first two factorial dimensions to the participant's string of lexemes. The contribution of the factorial dimensions was calculated by means of the cosine, which is a measure of the contribution of each factor to the object-row. More specifically, in the case of interest here, the cosine detects the proportion of the lexical meaning of the participant's string of lexemes due to the factorial dimension. Accordingly, the LMD consists of the sum of the cosines of the first two factors and can be interpreted as the contribution of these factors to the lexical meaning of the string of lexemes. As in the case of WISDD, the greater this contribution, the less the

contribution of the other factors, and the less the lexical meaning's dimensionality. Thus, the LMD is an inverted measure of dimensionality.

3.5. Data Analysis

Hypothesis 1 was tested by means of three regression models (forward stepwise method), each of which having a proxy of polarized, affect-laden meaning (i.e., ethnic identity scale, positive attitude towards foreigners, and punitive attitude) as dependent variable and WISDD and other control variables as predictors. More specifically, the following control variables were inserted as the first block: age, education, and three TIPI subscales (conscientiousness, agreeableness, and openness)—WISDD was inserted as the second block.

Hypothesis 2 was tested by means of one-way ANOVAs, having the experimental (DISSONANT) vs. control (CONSONANT) condition as factor and the LMD as dependent variable. Characteristics of participants and other measures related to the analysis were introduced as covariates to control their effects (details will be provided in the Results section, in reference to each analysis).

Given that we expected no interaction between the DISSONANT/CONSONANT and the IN-GROUP/OUT-GROUP condition, and that the OUT-GROUP was introduced to control a specific aspect of the design only (the assumption that the priming procedure was able to trigger the national identity frame), analyses were made in parallel for IN-GROUP and OUT-GROUP conditions.

4. Results

4.1. Hypothesis 1

Three regression models were carried out, each of them with one of the following variables as dependent variable: *positive attitude towards foreigners*, *ethnic identity*, *punitive attitude,* and WISDD as predictor. Age, education, TIPI personality traits—conscientiousness, agreeableness, and openness—were introduced as further predictors, as control. This was done because these variables could influence the relation between the dimensionality and its expression at the level of explicit attitudinal responses and beliefs.

None of the three models suffered from problems of collinearity (highest VIF = 1.168) and were all significant (F (2, 101) = 7.681, $p < 0.001$, F (4, 99) = 10.067, $p < 0.001$, F (2, 101) = 4.500, $p = 0.005$, respectively, cf. Table 1).

Table 1. Regression models. ANOVA test.

	Sum of Squares	*df*	Mean Square	*F*	Sig.
Regression Model 1. Dependent Variable: positive attitude towards foreigners. Predictors: within-individual semantic differential dimensionality (WISDD), age, education, conscientiousness, agreeableness, openness					
Regression	14.906	2	7.453	7.681	<0.001
Residual	97.998	101	0.970		
Total	112.903	103			
Regression Model 2. Dependent Variable: ethnic identity. Predictors: within-individual semantic differential dimensionality (WISDD), age, education, conscientiousness, agreeableness, openness					
Regression	177.688	4	44.422	10.067	<0.001
Residual	436.841	99	4.413		
Total	614.529	103			
Regression Model 3. Dependent Variable: punitive attitude. Predictors: within-individual semantic differential dimensionality (WISDD), age, education, conscientiousness, agreeableness, openness					
Regression	12.470	3	4.157	4.500	0.005
Residual	92.366	103	0.924		
Total	104.835	103			

Table 2 reports the main parameters of the regression model 1, with *positive attitude towards foreigners* as dependent variable and age, education, conscientiousness, agreeableness, and openness, and WISDD as predictors. The adjusted R square was 0.115 (std. err. of estimation = 0.985). Two predictors proved to be included in the model—openness (β = 0.307; t = 3.278; p = 0.001), and WISDD (β = −0.241; t = −2.575; p = 0.011). The distribution of residuals approximates the normal distribution.

Table 2. Regression model with *positive attitude towards foreigners* as dependent variable.

	B	Stand. Error	β	t	Sig.	VIF
Constant	−0.917	1.329		0.813	0.418	
Openness	0.163	0.050	0.307	3.278	0.001	1.019
WISDD	−3.318	1.289	−0.241	−2.575	0.011	1.019

WISDD = within-individual semantic differential dimensionality.

Table 3 reports the main parameters of the regression model 2, with *ethnic identity* as dependent variable and age, education, conscientiousness, agreeableness, openness, and WISDD as predictors. The adjusted R square was 0.260 (std. err. of estimation = 2.100). Four predictors proved to be included in the model—openness (β = −0.287; t = −3.129; p = 0.002), agreeableness (β = −0.232; t = −2.632; p = 0.01), age (β = 0.263; t = 2.964; p = 0.004), and WISDD (β = 0.183, t = 2.121; p = 0.036). The distribution of residuals approximates the normal distribution.

Table 3. Regression model with *Ethnic identity* as dependent variable.

	B	Stand. Error	β	t	Sig.	VIF
Constant	4.964	2.739		1.812	0.073	
Openness	−0.356	0.114	−0.287	−3.129	0.002	1.168
Agreeableness	−0.296	0.112	−0.232	−2.632	0.01	108
Age	0.044	0.015	0.263	2.964	0.004	1.096
WISDD	5.891	2.777	0.183	2.121	0.036	1.041

WISDD = within-individual semantic differential dimensionality.

Table 4 reports the main parameters of the regression model 3, with *punitive attitude* as dependent variable and age, education, conscientiousness, agreeableness, openness, and WISDD as predictors. The adjusted R square was 0.093 (std. err. of estimation = 0.961). Three predictors proved to be included in the model—education (β = −0.221; t = −2.339; p = 0.021), conscientiousness (β = 0.181; t =1.906; p = 0.059), and WISDD (β = 0.198, t = 2.085; p = 0.040). The distribution of residuals approximates the normal distribution.

Table 4. Regression model with Punitive attitude as dependent variable.

	B	Stand. Error	β	t	Sig.	VIF
Constant	−2.375	1.088		−2.182	0.031	
Education	−0.304	0.13	−0.221	−2.339	0.021	1.011
Conscientiousness	0.073	0.038	0.181	1.906	0.059	1.028
WISDD	2.624	1.258	0.198	2.085	0.04	102

WISDD = within-individual semantic differential dimensionality.

4.2. Manipulation Check

Preliminarily, it is worth noting that the experimental and control groups did not differentiate as to the five feelings associated to the five national identity-related objects. Indeed, we performed 25 one-way ANOVAs (one for each objects/feelings combination) and no difference was found (ANOVA outputs are reported in the supplementary materials; cf. SM2, Tables S1 and S2). These findings support the idea that the prime worked similarly among the two groups.

In order to check whether the manipulation was interpreted by participants consistently with the design, we compared the evaluation of the fictional feedback carried out by the experimental and control group. To this end, a MANOVA was performed, with DISSONANT/CONSONANT and IN-GROUP/OUT-GROUP as factors, and the four scales of evaluation of the fictional sample's response as dependent variables. In order to check the effect of the evaluation of the terrorist act, the score of punitive evaluation was introduced as covariate.

Experimental group (DISSONANT) evaluated the fictional feedback as less sharable (M(DISSONANT) = 2.933, SD(DISSONANT) = 1.543, F (1, 117) = 63.598, $p < 0.001$, MSE = 2.210), less right (M(DISSONANT) = 3.800, SD(DISSONANT) = 1.785, F (1, 117) = 17.506, $p < 0.001$, MSE = 2.526) and tending to be more uncertain (M(DISSONANT) = 3.400, SD(DISSONANT) = 1.732 F (1, 117) = 3.408, $p = 0.067$, MSE = 2.404) than the control group (CONSONANT). No significant difference was found on the scale of predictability. IN-GROUP/OUT-GROUP and the DISSONANT/CONSONANT*IN-GROUP/OUT-GROUP interaction did not show significant difference.

4.3. Hypothesis 2

Hypothesis 2 was tested by means of a one-way ANOVA applied to the IN-GROUP condition, with the LMD as dependent variable and the DISSONANT/CONSONANT as factor. The number of words was introduced as covariate, to control this aspect. Moreover, the following covariates were introduced: (a) socio-demographic (age, education) and psychological (TIPI personality traits: conscientiousness, agreeableness, and openness) characteristics; (b) positive attitude towards foreigners; and (c) punitive evaluation. This was done because these facets could work as sources of bias: they can influence the value attributed to the dissonant fictional feedback, both directly—e.g., openness could reduce the negative impact of the dissonant feedback; agreeableness could work in the opposite direction; being disconfirmed in one's benevolent or punitive attitude could have a different meaning for the person receiving it—or indirectly—e.g., openness and positive attitude towards foreigners could moderate the negative evaluation of the terrorist act and, therefore, the impact of the disconfirmation of its evaluation, while conscientiousness could work in the opposite direction; again, age and education as well as personality traits could moderate the subjective relevance of the national identity frame and, in this way, the impact of its disconfirmation/confirmation.

Leven tests of homoscedasticity proved to be not significant. The ANOVA showed a significant main effect: the experimental group (DISSONANT condition) showed higher LMD (therefore, lower dimensionality) than the control (CONSONANT condition) (F (1; 28) = 4.175; $p < 0.048$; partial eta square = 0.099; observed power = 0.513).

The parallel ANOVA comparing DISSONANT/CONSONANT conditions, performed on the OUT-GROUP condition showed no significant effects.

5. Discussion

Findings were consistent with both hypotheses.

The semiotic dimensionality model claims that the low-dimensional MPS is the computational correspondent of the polarized affect-laden meaning. Hypothesis 1 was aimed at testing this statement. The output of the regression models supports it. In all three models the dimensionality of the meaning underpinning the responses to the semantic differential task (performed before the experimental manipulation) proved to be associated with the intensity of beliefs and attitudes about the socio-institutional world—the ethnic conception of identity, the positive attitude towards foreigners, the punitive attitude (expressed towards the person responsible for a terrorist act). More particularly, the beta coefficients showed that the lower the dimensionality (i.e., the higher the WISDD), the lower the attitude of positive opening towards foreigners, and the higher both the ethnic identity and the punitive attitude.

The affect-laden nature of these three constructs has been widely recognized. For instance, the ethnocentrism implied in the high score of ethnic identity proved to be related with feelings of anomie and authoritarianism (e.g., Heydari et al. 2014; Scheepers et al. 1990) as well as to co-occur with affective polarization, social intolerance, and refusal to cooperate with out-groups (McCoy et al. 2018). Salvatore and colleagues (2019c) found that the negative attitude towards foreigners is related with the most affect-laden symbolic universes. The punitive attitude is in itself a form of affective response; moreover, it proved to be related with several forms of affect-laden attitudes and beliefs—e.g., prejudice (Pettigrew 1979), polarized ideology (Womick et al. 2019), and vindicability (McKee and Feather 2008). Thus, one has grounds to conclude that affect-laden beliefs and attitudes are associated with a low-dimensional meaning. This conclusion is consistent with the interpretation of the current socio-institutional scenario characterized by the high momentum that simplified affect-laden meanings—notably the friend/foe schema—have gained in the contemporary socio-institutional sphere (Cremaschi et al. 2021; Mannarini and Salvatore 2020; Salvatore et al. 2019d, 2021a).

Hypothesis 2 concerns the other SDM core tenet—the idea that meaning-makers respond to uncertainty by reducing the dimensionality of the meaning they adopt to interpret the context of their meaning-making. This hypothesis found support in the results. After the checking of the participants' characteristics (age, education, personality traits, and attitude towards foreigners) and the task-related aspects (the punitive attitude in the evaluation of the terrorist act, and the number of words produced during the associative task), the experimental group—i.e., participants subjected to disconfirming fictional feedback—performed a lower-dimensional lexical meaning task than the control group in the free association task. This leads us to conclude that the uncertainty generated by the disconfirmation induced a decrease in the dimensionality of the mental phase space in the participants subjected to it.

Of note, the fact that the meaning used as dependent variable was that produced by the free association task is consistent with the idea that it concerns the contextual level of meaning. This idea is based on the psychoanalytic view of free associations as a major way to reconstruct the affect-laden meaning of the interpersonal context (Etchegoyen 2005); more in general, it is grounded on the recognition that the meaning produced during the free association task can be considered to reflect the meaning-maker's global state of mind, namely, the meaning in terms of which meaning-makers interpret the context in which they are embedded (Salvatore and Freda 2011).

The interpretation of the findings as indicative of the causal relation between uncertainty and a decrease in dimensionality of the mental phase space is supported by the output of two complementary analyses. First, the manipulation check confirmed that, as assumed by the design, participants perceived the disconfirming feedback and believed it real. Indeed, participants asked to evaluate the feedback and their responses testify that they were aware of its confirming/disconfirming valence and that their reactions were consistent with the conclusion that they took the content of the feedback seriously.

Second, findings concerning the OUT-GROUP control condition give robust, though indirect, support to the idea that, in the experimental condition (i.e., the DISSONANT/IN-GROUP) what was disconfirmed was the Italian national identity frame. As already said, participants in the OUT-GROUP were told that the fictional feedback had been provided by extra-EU foreigners living in Italy (rather than by Italian people, as in the IN-GROUP). The fact that the dissonant fictional feedback had no effect on the OUT-GROUP condition implies that the disconfirmation effect found in the IN-GROUP condition was due to the qualification of the fictional feedback as coming from Italian people. It follows that the effect of the dissonant feedback in the IN-GROUP was due to the fact that such feedback destabilized a meaning related, and, therefore, sensitive to, the "Italian-ness" of the feedback—what we have named the Italian national identity frame. Accordingly, participants of the OUT-GROUP condition did not use the national identity frame to forecast the foreigners' response and, therefore, the dissonant feedback did not destabilize it. Thus, one has grounds to conclude that the lack of effect of the dissonant feedback in the

OUT-GROUP condition supports the study's methodological assumption that the research setting was able to induce uncertainty by priming the identity national frame, and then destabilize it by means of the dissonant fictional feedback.

The findings discussed above are the first empirical test of the semiotic dimensionality model. They present several points of interest. First, they encourage efforts in the direction of developing and validating the model, which has several aspects of specificity with respect to the current socio-cognitive theories of uncertainty.

First, the SDM adopts a particular definition of uncertainty that, it seems to us, facilitates its operationalization and computational modelling as well as helping to clarify the boundaries with related concepts (for a discussion of the conceptual specificity of the notion of uncertainty, see Carleton 2016). The SDM definition of uncertainty is different from the goal-oriented definition—e.g., as lack of control (Kay et al. 2008), impossibility to have one's needs satisfied (Martin 1999), inability to process causal inferences concerning social events (Weary et al. 2010), and threat—e.g., as a trigger of anxiety (McGregor et al. 2010; see also Monat et al. 1972, p. 237, cited in Greco and Roger 2001), as fear of the unknown (Carleton 2016). Instead, the SDM definition partially overlaps both the view of uncertainty as destabilization of the self—e.g., self-uncertainty (Hogg 2007; van den Bos 2009), threat to self-esteem (Leonardelli and Lakin 2010) as well as death salience (Greenberg and Arndt 2011), when the latter is interpreted as a form of threat to the sense of self (van den Bos 2009). It also overlaps the view of uncertainty as violation of meaning—as failure of meaning (Proulx and Inzlicht 2012), violation of worldview (worldview violation model; Major et al. 2007), exposure to environmental complexity (Peterson and Flanders 2002), and increased entropy (Hirsh et al. 2012). However, it retains specificities with respect to the latter definitions, too. Indeed, firstly, differently from models focused on the self, the domain meaning is subjectively relevant for the meaning-maker: it fosters the sense of continuity of experience through the on-going meaning-making (Valsiner 2020), yet it does not consist of the whole concept of oneself, but can be seen as the component of the self that the meaning-maker activates locally to ground the current engagement with the world. This means that the destabilization of the domain meaning locally destabilizes the self, too, even it does not necessarily mean that what is violated is the overarching, diachronic sense of oneself. Secondly, the SDM focuses on the contextual level of meaning. In this it is different both from models such as compensatory control theory (Landau et al. 2015) and the causal inference model (Weary et al. 2010)—which focus on the meaning involved in the interpretation of discrete objects, events, and goals—and from the meaning maintenance model (MMM, Proulx and Inzlicht 2012), which conceives the violation of meaning in a holistic way as the failure of expected relationships, which produces a global undermining of the sense of meaningfulness of the experience.

However, it is worth adding that the SDM does not enter competition with either the definition of uncertainty or the socio-cognitive responses provided by other models. This is because the SDM focuses on the computational modelling of the meaning-making process underpinning the socio-cognitive effect of uncertainty. Accordingly, its aim is to provide an integrative meta-framework that models the mechanisms and, therefore, the conditions by which the many forms of uncertainty so far investigated by the literature are able to generate certain kinds of socio-cognitive responses. For instance, we conjecture that lack of control, death salience, as well as personal uncertainty can be viewed as manifestations at the level of content, of low-dimensional domain meaning induced by specific contextual conditions, which, in turn, frame the socio-cognitive responses that these models have detected.

A second element of specificity of the SDM is the role it attributes to affects in the management of uncertainty. Most models focus on the effect of the destabilization induced by uncertainty—e.g., aversive arousal—and they see the responses to it as the way to cope with this effect. In contrast, the SDM aims at modelling the way the meaning-maker processes this destabilization in order to overcome it—rather than to cope with its effect. This difference is evident when the SDM is compared with the MMM (Proulx and Inzlicht 2012), perhaps, the model with which it has most similarities. Both models adopt a comprehensive

view of meaning, recognize the variety of the socio-cognitive responses, and highlight the mediational role of affects. Yet in the case of the MMM, restorative meaning-making is activated after the violation, as a reparative palliative strategy to cope with the aversive arousal generated by the violation. On the other hand, for the SDM the restoration of meaning is the on-going process through which the meaning-maker modulates its meaning-making in order to stabilize it instant by instant, to keep it attuned to the increased complexity of the environment that constitutes uncertainty. In the final analysis, according to the SDM, meaning functions as an organizationally closed system (Maturana and Varela 1980; on meaning as an operationally closed system, see Salvatore 2020)—it is not violated, but perturbed; it does not break down, but reorganizes itself to combine with the new environmental contingency.

To use an analogy, according to the MMM (and other models), the meaning-maker is similar to a person who, having lost an important object, turns to a surrogate for it or tries to think of other matters to avoid feeling sorrow; by contrast, the SDM envisages the meaning-maker as a person, who, having lost the object, strives to retrieve it, by thinking of where and how it could have gone missing. In this sense, the SDM agrees with Rutjens et al. (2013, p. 254), when they say that:

> "(. . .) it remains to be seen whether compensatory beliefs and preferences primarily provide compensation (so that the threat remains but the person is better equipped to psychologically cope with it or is inoculated against it) or actually regulate the threat (so that the threat is effectively removed)."

Finally, it is worth highlighting a general theoretical implication one can draw from the SDM, and, in particular, from the last statements about the operational closure of meaning. Indeed, at the basis of the model there is the assumption of the inherent self-referentiality of the cognitive system—the meaning-maker first has to keep its contextual interpretation stable; the heuristic quality of the interpretation, namely, its content of truth, its utility for the individual and social adjustment come after and can be sacrificed in order to protect/restore the stability of the meaning. To use the analogy proposed above, the cognitive system operates similar to the player who prefers to win a bet even if it means not winning the big prize. In this respect, the SDM agrees with the MMM idea that the cognitive response to uncertainty is aimed at restoring the sense of stability of the system of meaning, rather than solving the lack of knowledge that makes up the uncertainty. However, the SDM differs from the MMM because the former attributes a direct and endogenous role to the affects in the response to uncertainty. Indeed, while the MMM assumes that the affects (intended as aversive arousal) are what motivates the restoration, but do not contribute to it, the SDM holds that the affects (intended as affective meanings) are the component of the cognitive system directly involved in the restoration. In the final analysis, while the MMM sees affects as the reaction to uncertainty, the SDM sees them as the semiotic regulator of uncertainty.

The interest of the SDM is not only theoretical; indeed, it provides a key to gain a deeper understanding of the many phenomena of high momentum of affective meaning-making in contemporary societies—e.g., hate crimes, xenophobia, and so forth. According to the framework provided by the SDM, these manifestations can be seen as forms of the dramatic decrease in the dimensionality of meaning exchanged in the public arena, triggered by and aimed at coping with the disruptive impact of the uncertainty conveyed by the socio-cultural turmoil induced by globalization (Salvatore et al. 2019d, 2021a). The most evident expression of this socio-cultural dynamics is provided by the momentum gained by the foe/friend schema at any level of the contemporary social life—from interpersonal changes to the relationship between States. What counts about the other is simply whether or not it is part of the in-group: all qualities are drawn from this single categorization. Whatever "the other" is: be it migrants, EU institutions, Islamic people, Russia, supporters of the rival soccer team, the person with whom one is arguing over a parking space, and so forth—more and more the interpretation of any form of otherness ends up being one-dimensional: if it is not a friend, it cannot be but an enemy, one that conveys all the

negative qualities, first of all, that of being against us. No intermediate views, no nuance, no variability find space in this one-dimensional framework that transforms each social exchange into a boxing match.

The SDM computational reading of the affectivization of the public arena can help not only to build a comprehensive understanding of the current socio-institutional scenario; it suggests how to counteract the current rampant affectivization characterizing it. Indeed, from the SDM one can draw the idea that to cope with the increased momentum of affective meanings, institutions should work as the hub of innovative domain meanings—e.g., ideas, values, narratives, and social practices—empowering the meaning-makers' capacity to make sense of the growing contextual variability (Cremaschi et al. 2021). Indeed, the more these domain meanings provide meaningful understanding of the current social complexity, the more they function as semiotic buffers against uncertainty, therefore, reducing the need to resort to the simplified solution of reducing the dimensionality. To give just one example, Cremaschi and colleagues (2021) report the case of the way an Italian municipality (Bozen) has recently governed the discussion around a monument built by the Fascist regime to celebrate the WWI victory. Recently, the monument raised a new wave of debate, characterized by the polarized juxtaposition between those who interpreted it a sign of the Fascist past and of the nationalist ideology and, therefore, demanded its destruction and those who defended it, claiming that it was, however, a piece of the story of the city. The municipality found a "third" point of view, not coinciding with those in conflict: by means of minimal interventions—e.g., a light was installed evoking the no-entry road signal—it was re-signified. In so doing, it is now a monument that conveys a two-level message: the original nationalistic pride but also the invitation to see this identity motive as relative. In brief, by means of the re-signification of the monument, the municipality developed an innovative meaning, of higher dimensionality—where previously the valorization of the past and its critical revisitation were juxtaposed, now they can go together.

Limitation and Future Research Directions

The fact that the findings of the study are encouraging does not lead us to underestimate the limitations that affect its generalizability. The study recruited participants from just one country and the effects we found, though significant, were rather small. Moreover, it has to be recognized that the prime effect was tested only indirectly and that the design implemented a limited set of moderators and dependent variables. Therefore, further studies are needed, in order to replicate current results and to explore the role of further factors (e.g., the worldviews with which participants are identified; the level and valence of the affective arousal associated with the induced uncertainty) in terms of different designs, samples, and control conditions. More particularly, we see three major points that need to be addressed. First, the dynamics of uncertainty. So far, the SDM states that uncertainty consists of the destabilized impact of an increasing contextual complexity on the meaning-maker's system of meaning. However, a more fine-grained understanding of this dynamic mechanism is needed: how can the environmental complexity be modelled? How is it computed by the meaning-maker? What does the destabilization impact consist of exactly? In brief, we need a computational model of the dynamic interface between the uncertainty environment and the meaning-maker's apperception of it. Second, the intertwinement between individual, interpersonal, and social levels of the semiotic regulation of the uncertainty. The SDM is a cultural psychological theory—it assumes that the domain meanings are cultural resources which the meaning-maker uses, and this happens in the context of social practices regulated by normative frameworks (Cremaschi et al. 2021). Yet, there are reasons to think that any meaning-maker tends to adopt a certain dimensionality as baseline (for an interpretation of the psychopathology based on this view, see Venuleo et al. 2020)—in the final analysis, the phase space of meaning needs to be seen as being both within and amongst individuals. Thus, we need to deepen our understanding of how the dimensionality of the mental phase space is stable within the individual, and how it varies due to circumstances, and what mechanisms mediate the

dialectics between stability and situatedness. Third, there is the bivalence of uncertainty. Indeed, the previous pages focused on the simplified impact of uncertainty, on its effect of decreasing the dimensionality of meaning. Uncertainty was, therefore, regarded as leading to affectivization, therefore, to subjective and social circumstances characterized by the weakening of rationality, in brief, as a negative factor for people and institutions. However, this is only one side of the coin. Very many psychological theories tell us that a certain degree of destabilization of the cognitive structure and/or system of meaning is what triggers innovation and development. Just to mention a few examples, consider the Piagetian concepts of cognitive conflict and accommodation, as well as the view of the psychotherapy change as due to the attuned destabilization of the patient's system of meaning introduced by the therapist. So, we need to understand what, how, and what makes the difference between the uncertainty leading to the decrease in dimensionality and the uncertainty that promotes a complexification of meaning, namely, innovative, progressive change. There is no need to point out how relevant this question is, for both theoretical and practical reasons. We have reason to think that it provides the way to reach a general psychological theory of change.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/socsci12040217/s1.

Author Contributions: S.S., additionally to supervision, together with T.M., A.G., R.D.L.P., A.P., F.P., are responsible for conceptualisation and design of the study; A.G., J.R.K. and S.K., managed software, methodology and analysis; S.I., G.C. and A.R. contributed to investigation; S.D.D., M.R., G.R. were involved in writing review and editing. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study received the ethical clearance by the Ethical Committee of the department of Dynamic and Clinical Psychology, and Health Studies of "Sapienza" University (Prot. n. 0000226, 27 February 2020) and was in accordance with the standards of the Declaration of Helsinki.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Conflicts of Interest: The authors declare no conflict of interest.

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