Evaluating a Field Theory of Consciousness and Social Change: *Group Practice of Transcendental Meditation and Homicide Trends*

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Abstract

This study outlines and empirically tests a field-theoretic view of consciousness and positive social change based on the ancient Vedic tradition of knowledge from India (*Veda* means "knowledge" in *Sanskrit*) as brought to light by the Vedic scholar and scientist of consciousness, Maharishi Mahesh Yogi. In contrast to most contemporary theories of mind and consciousness originating in the West, Maharishi's Vedic science of consciousness posits the existence of an interpersonal, nonlocalized dimension of consciousness that underlies both individual consciousness and the "collective consciousness" of society, or "national consciousness." We review previous empirical tests in Cambodia, India, the Philippines (and other countries) of hypotheses derived from this field-theoretic view of consciousness. We then present new empirical results, which together with prior research, provide evidence for an interpersonal dimension to consciousness. Segmented-trend regression analysis of data from a prospective, 15-year U.S. national social experiment found support for the hypothesis that "field effects of consciousness" created by group practice of Transcendental Meditation® and its advanced technique, the TM-Sidhi® program, by a theoretically predicted number of participants contributed to a reduction in social stress in national consciousness as indicated by improved monthly homicide trends during the study's experimental period 2007-2011 ($p < .0001$). These results are consistent with significant reductions in crime and violence associated with group practice of the TM® and TM-Sidhi® program as reported in previous peer-reviewed research. This reduction was followed by a predicted subsequent increase in homicide trends 2012-2016 ($p < .0001$) after the group fell below the required size (approximately the √1% of the U.S. population).

Keywords: consciousness, social stress, homicide, Transcendental Meditation, social experiment

1. Introduction

Most contemporary scientific theories of consciousness and mind originating in the West assume that consciousness is private in nature as opposed to being a shared phenomenon. This is true whether theories are cognitive (Baars, 1997; Dennet, 2013), neurophysiological (Damasio, 2012; Edelman, 1992; Edelman & Tononi, 2000) or mathematical (Oizumi, Albantakis, & Tonoi, 2014; Rudrauf et al., 2017; Tononi, 2012). An exception is the case of some physicists (e.g., Goswami 1995, 2001; Kastrup, Stapp, & Kafatos, 2018) and biomedical scientists (e.g., Theise & Kafatos, 2016; Van Lommel, 2011). Even in the case of the most generous type of the "external mind" hypothesis, consciousness is viewed as interior, while external phenomena may contribute to cognitive processes such as memory and language (Clark & Chalmers, 1998).

Unlike these ideas, this study outlines and empirically tests a field-theoretic view of consciousness and positive social change based on the ancient Vedic tradition of knowledge from India (*Veda* means "knowledge" in *Sanskrit*) as brought to light by the Vedic scholar and scientist of consciousness, Maharishi Mahesh Yogi. In contrast to most Western theories of mind and consciousness, Maharishi's Vedic science of consciousness posits the existence of an interpersonal, nonlocalized dimension of consciousness that underlies and influences both individual consciousness, or individual mind, and the "collective consciousness" of society. This study reviews previous empirical tests in

Cambodia, India, Philippines, and other countries of hypotheses derived from this field-theoretic view of consciousness and presents new empirical results that provide evidence for an interpersonal dimension to consciousness.

1.1 Precedents in Western Social Science

Unlike the contemporary theorists mentioned above, in some cases founders of psychology and sociology made clear that they posited an intersubjective dimension to consciousness, for example, Fechner and Durkheim. Gustav Fechner (1801-1887) is known as the originator of the psychophysical method and one of the founders of experimental psychology. Less known is his position on consciousness. As pointed out by James (1898/1977), Fechner proposed that the individual's psychophysiological "threshold" determined if the experience of the continuity of consciousness is gained. Fechner noted, "One of the most important problems and tasks of Psycho-physics now is this: to determine the conditions under which the cases of continuity and discontinuity occur" (James, 1898/1977, pp. 60-61). Fechner drew an analogy in which there is a single ocean on which waves occur, waves that appear discontinuous, and proposed that if the threshold were altered, the continuity of consciousness might be experienced: "…and the discontinuity of the consciousness would be converted into continuity. We of course cannot bring this about" (James, 1898/1977, p. 65). Fechner's legacy of the psychophysiological method has continued, yet his theoretical premises about consciousness have fallen off, perhaps the result of inability to change the psychophysiology to experience the "continuity" of consciousness.

Emile Durkheim presents a different picture of the underlying unity of consciousness. To Durkheim, the French social thinker often cited as a founder of scientific sociology, the *conscience collective* was the indicator of the social fabric uniting individuals in society. Durkheim defined *conscience collective* as "the set of beliefs and sentiments common to the average members of a single society [which] forms a determinate system that has its own life" (Lukes, 1973, p. 4). Although Durkheim is usually viewed from a more materialist perspective, it is interesting to consider his own words. Durkheim (1951) viewed conscience collective as occurring when "the consciousness of individuals, instead of remaining isolated, becomes grouped and combined," resulting in social "representations" or "states of mind" that "are qualitatively different from individual ones" and "are in a sense exterior to individuals" (pp. 310-313). This sounds a lot like the "external mind" hypothesis, except that the individual's consciousness is seen as the source of representations when it becomes combined with that of others. Durkheim viewed the consistency of suicide rates as evidence for his theory, although this perspective has been insufficient for these concepts to continue to guide sociological thought.

One of the founders of social psychology, William McDougall (1920), discussed the concept of "group mind" such as the *esprit de corps* of an army, or the mind of other social groupings. He also proposed the concept of "national mind" characterized by both affective and mental aspects.

Common expressions that refer to the concept of a collective aspect of consciousness, or group mind, include, "employee morale" in business, "investor sentiment" in finance, "team spirit" in sports, and "public opinion" or "national mood" in public opinion polling. Research motivated by such concepts includes, for example, a recent series of empirical studies in behavioral finance that has investigated the relationship between measures of national mood and stock market performance (e.g. Edmans, Fernandez-Perez, Garel, & Indriawan, 2021). Edmans et al. (2021) use the sentiment of songs that people listen to on online music sites as a proxy measure for national mood. Related studies have also examined the association between stock market behavior and mood-affecting events, such as aviation disasters, weather, and outcomes of sporting events.

In other recent research, the Global Consciousness Project at Princeton University's Engineering Anomalies Research Lab has conducted studies for more than twenty years that have found empirical evidence said to support the existence of global consciousness (Nelson, 2019).

In the following section we discuss the view of consciousness from the Vedic tradition of knowledge of consciousness as revived and reinterpreted by Maharishi Mahesh Yogi. This Vedic perspective postulates the existence of a fundamental, transcendental field of consciousness that underlies both individual consciousness or individual mind and the national mind or "collective consciousness" of society. Another important distinguishing feature of Maharishi's revival of Vedic knowledge is that it proposes an evidence-based procedure to systematically experience and enliven this underlying transcendental field for the purpose of alleviating individual and social stress and tensions, promoting positive change in individual and national consciousness, and thereby improving societal quality of life (QOL). Although this Vedic approach has its roots in the East, it is said to be a universally applicable science and technology of consciousness that is applicable and effective for those of any culture or way of life.

1.2 The Vedic View of Consciousness

The Vedic tradition has been acknowledged to be the oldest of the living systems of knowledge (Basham, 1959, p. 4). In the Vedic perspective, consciousness is viewed as having an interpersonal reality as well as a personal one; experience of the interpersonal dimension of consciousness is said to require extensive practice of meditation procedures intended to unfold latent potentialities of human consciousness (*Bhagavad Gita*, 1897/1977; Maharishi Mahesh Yogi, 1969; Sankaracharya, 1977; *The Principle Upanishads*, 1974); these procedures involve progressive refinement of mind and body (Egenes, 2010; Maharishi Mahesh Yogi, 1969). Although the Vedic conception of consciousness has been inspiring for a number of thinkers within the behavioral and physical sciences, until the 1970s empirical research motivated by this perspective was limited by the lack of effective procedures for systematic, repeatable experience of the interpersonal level of consciousness.

During the past half century, Maharishi Mahesh Yogi (1917-2008) revived the Vedic procedures for development of consciousness, organized the teaching of millions of people, inspired scientific research on their results (e.g., Dillbeck, Barnes, Schneider, & Travis, 2020), and expressed the Vedic principles in terms that are testable. Maharishi's comprehensive revival of the Vedic knowledge of consciousness has been termed "Maharishi's Vedic Science and Technology (MVST)."

Recently, Harvard and MIT-trained neuroscientist Tony Nader has formulated the fundamental principles expressed in Maharishi's Vedic science of consciousness in an axiomatic framework of formal logic (Nader, 2015, 2021). Mathematical formulations of concepts from MVST have been proposed by Corazza (2017). Also, Nader (2000, 2012), working under the inspiration and guidance of Maharishi, has proposed relationships between the Vedic view of consciousness and the structure and function of human physiology. Independently, physicist Amit Goswami (1995, 2001), like other leading quantum physicists before him such as Erwin Schrödinger and others (Oates, 2020), has been inspired by the Vedic literature on consciousness to discuss its connections with quantum physics and to suggest that consciousness, not matter, is the ground of all existence.

In MVST, consciousness is seen not as an emergent property of matter produced through the functioning of the human nervous system, but rather as fundamental in nature (Nader, 2021). Pure consciousness is viewed as the essential nature of life—an unbounded, unified field of pure intelligence, beyond space and time—which gives rise to all expressed values in the universe, both subjective and objective (Maharishi Mahesh Yogi, 1969; Nader, 2015, 2021). This field of nature's intelligence is said to be the unified, transcendental source of all the laws of nature that govern the evolution of human life and the entire universe (Maharishi Mahesh Yogi, 1986a, pp. 163-164; Nader, 2015, 2021). MVST posits the existence of an interpersonal, nonlocalized field of consciousness ("pure consciousness," "pure awareness," or "transcendental consciousness") that underlies both individual consciousness and the "collective consciousness" of society. Collective consciousness is defined as the wholeness of consciousness of the individuals comprising the entire social group: family, city, province, or nation. Maharishi explains that there exists a reciprocal relationship between individual consciousness and collective consciousness in which each influences the other. The collective level of consciousness is seen as the principal determinant of societal quality of life and of social dynamics and change (Maharishi Mahesh Yogi, 1977, 1978, 1986a).

In the current study, we review previous empirical tests in Cambodia, India, the Philippines, and other countries of hypotheses derived from this field-theoretic view of consciousness and present new empirical results, which together with prior research, provide evidence for an interpersonal dimension to consciousness. We analyze data from a prospective, 15-year, national social experiment to empirically assess two testable hypotheses derived from this Vedic perspective. First, we evaluate the prediction that "field effects of consciousness" created by group practice of the Vedic procedure for experiencing pure consciousness (Maharishi's Transcendental Meditation and TM-Sidhi® program) by a sufficiently large number of participants would contribute to a reduction in social stress as indicated by reduced trends in monthly U.S. homicide rates during the "experimental period" 2007-2011. Improved homicide trends were assessed relative to a five-year baseline period. Second, we test the prediction that monthly homicide trends subsequently would begin to increase when the size of the group declines markedly in the "post-experimental period" 2012-2016.

In the remainder of this paper first we outline Maharishi's Vedic science of consciousness in greater detail and explore its implications for social change. Then we discuss the peer-reviewed empirical literature that has investigated impacts of postulated field effects of consciousness on crime, violence, and other negative trends in societal quality of life (QOL). Next, we describe the data, methods, and research hypotheses associated with the prospective social experiment and then present the empirical results. Finally, in the discussion section we consider possible alternative explanations

for our findings, the relationship of field effects of consciousness to field effects studied in physics, and the role of scientific anomalies in scientific progress.

2. Maharishi's Vedic Science of Consciousness

2.1 Experience of Pure Consciousness: Transcendental Meditation

A foundational aspect of MVST is the Transcendental Meditation (TM) technique, which Maharishi (1986b) introduced to the West in the mid-1950s. It is said to provide a systematic procedure for allowing the individual mind to consciously contact the universal level of consciousness—pure consciousness or transcendental consciousness. TM is described as a simple, natural, mental procedure practiced twice daily for 15-20 minutes with eyes closed that is suitable for those of all cultural, religious, ethnic, and educational backgrounds (Roth, 2018). Maharishi explains that this procedure allows the individual to experience pure consciousness by "turning the attention inwards towards the subtler levels of a thought until the mind arrives at the source of thought" (Maharishi Mahesh Yogi, 1969, p. 470). Pure consciousness, the unified source of thought, is experienced when the mind settles down to a mode of inner silence in which the division of knower, known, and the process of knowing is transcended and awareness opens to itself alone (Pearson, 2016; Travis & Pearson, 2000).

As described by Travis and Shear (2010), meditation practices are characterized by different procedures, differing purposes, and different patterns of EEG and other brain activity. Meditations in the "Open Monitoring" category, such as mindfulness meditation and Zazen, instruct practitioners to simply be aware of the moment-by-moment flow of subjective experiences. The "Focused Attention" category includes meditation techniques that seek to control the mind and, for example, keep it focused on breathing (Vipassana), the body (Zen), or the feeling of pure compassion and loving kindness (compassion and loving kindness meditation). TM is in the "Automatic Self Transcending" category, which includes techniques that transcend the steps of meditation practice—going beyond the finest impulse of thought to experience pure consciousness, transcendental consciousness, pure inner wakefulness.

The increased inner wakefulness during TM has been shown to correspond to a unique psychophysiological state of restful alertness and reduced stress during the practice (Travis & Pearson, 2000). More than 380 peer-reviewed studies on a wide range of physiological, psychological, and sociological effects of this practice have been published in more than 160 scientific journals. An online database of articles published in eight volumes of collected research papers on TM and the TM-Sidhi program (e.g. Dillbeck et al., 2020) is provided at https://researchtm.net/.

Reduction of stress on the individual level provides a first line of defense against collective, or social, stress. There is extensive evidence that TM reduces individual stress. The physiological effects of this meditation technique are the opposite of those produced by stress. The classic "Fight or Flight" response posited in the 1930s by Harvard physiologist Walter Cannon is characterized by increases in heart rate, breathing rate, and elevated secretion of stress hormones such as plasma cortisol (Cannon, 1939). By contrast, meta-analyses and numerous studies have found that these parameters are reduced during TM significantly more than during ordinary rest (Dillbeck & Orme-Johnson, 1987; Klimes-Dougan et al., 2020; MacLean et al., 1997).

Also, regular TM practice has been found to habituate the physiology to function in a more relaxed manner outside of meditation, as indicated by lower blood pressure (Rainforth et al., 2007); reduced cortisol (Klimes-Dougan et al., 2020); lower baseline heart rate and respiratory rate, decreased spontaneous skin resistance responses, and lower plasma lactate (Dillbeck & Orme-Johnson, 1987); and fewer strokes, heart attacks, and death (Schneider et al., 2012). Longitudinal effects that indicate reduction of stress include reduced symptoms of depression and PTSD (Nidich et al., 2018), decreased anxiety (Orme-Johnson & Barnes, 2014), decreased aggression and hostility in prison inmates (Hawkins, Orme-Johnson, & Durchholz, 2005), and reduced recidivism by convicted felons (Rainforth, Alexander, & Cavanaugh, 2003).

The conceptual opposite of "stress" is "coherence," which on the individual level means harmonious functioning of the different mind-body systems such that all the various parts support the health and growth of the whole, and the whole supports the parts of the system. The list of indicators of reduced stress mentioned above can be viewed as providing an operational definition of what individual coherence means: less depression, less anxiety, less anger, less waste of adaptive energy, and greater mental and physical health. Also, coherence is indicated by increased coherence in alpha 1 EEG frequency (8-10 Hz), which has been shown to be correlated with higher levels of intelligence, concept learning, moral reasoning, and reduced neuroticism and anxiety (Dillbeck, Orme-Johnson, & Wallace, 1981; Orme-Johnson & Haynes, 1981; Travis & Arenander, 2006).

From the theoretical perspective of the current study, such stress reduction in the individuals of society is said to result in reduced stress in the larger society. But according to this perspective, only a small fraction of the population needs to practice TM in order to have an effect of reduced social stress. The reductions in stress and increased coherence in individuals practicing TM and its advanced techniques are said to be transmitted to others in the population via nonlocal, field effects of consciousness (see next two sections).

2.2 Maharishi on Collective Consciousness

From the perspective of the Vedic understanding of consciousness as brought to light by Maharishi, just as the behavior of each individual depends on the quality of individual consciousness, the quality of behavior in society is seen as an integrated expression of the quality of what Maharishi terms the "collective consciousness" of the nation (Maharishi Mahesh Yogi, 1977, p. 91). Each level of society—family, community, city, state, nation, or the entire world—is described as having its own characteristic collective consciousness, which is the wholeness of consciousness of the individuals comprising the entire group (Maharishi Mahesh Yogi, 1977, p. 91). The common basis of individual consciousness and collective consciousness is said to be the universal, underlying field of pure consciousness (Maharishi Mahesh Yogi, 1985, pp. 56-76).

Maharishi further explains that individual and collective consciousness reciprocally influence each other (Maharishi Mahesh Yogi, 1977, p. 105). Due to this reciprocal relationship, changes in stress and tension in individual consciousness will be mirrored in the quality of collective consciousness, and vice versa (Maharishi European Research University, 1982, p. 6; Maharishi Mahesh Yogi, 1978, pp. 258-262).

From the point of view of society, the consequence of the accumulation of stress in individual and collective consciousness is said to be that societal problems such as crime, conflict, violence, accidents, and other negative trends become more prevalent in society: "If the collective consciousness of the country is under stress, then incoherent and conflicting tendencies will predominate in society and problems, turbulence, and violence will characterize the nation (Maharishi University of Natural Law, 1982, p. 8)." The discussion in this section and the next draw heavily on Cavanaugh, King, & Titus (2011).

2.3 Transforming Collective Consciousness

2.3.1 Phase Transition Model

Because pure consciousness is posited to be the common basis of both individual and collective consciousness, enlivenment of pure consciousness in individual awareness through Maharishi's technologies of consciousness is said to also enliven pure consciousness at the basis of collective consciousness (Maharishi Mahesh Yogi, 1978, pp. 258-260). As early as 1962 Maharishi suggested that even a small percentage of the population practicing the TM technique—on the order of approximately 1%—would be sufficient to reduce social stress and produce a positive influence on the quality of life of the whole society, whether city, province, nation, or the world (Maharishi Mahesh Yogi, 1986b). The prediction that even a small fraction of a population practicing TM would reduce societal stress and positively influence societal QOL was later termed the "Maharishi Effect" by scientists investigating this hypothesis. We refer to this prediction as the "1% effect."

In 1976, Maharishi introduced a short cut to creating the 1% effect in society: the TM-Sidhi program, an advanced technique of Transcendental Meditation. The TM-Sidhi program is described as a procedure to train the individual to think and act from the level of pure consciousness and accelerate the individual's development of consciousness (Dillbeck & Alexander, 1989; Maharishi Mahesh Yogi, 1969). Maharishi predicted that a group consisting of approximately the square root of 1% ($\sqrt{1\%}$) of the population practicing this more powerful advanced program together in one place would produce the same beneficial effects of reduced social stress and improved societal QOL predicted when approximately 1% of individuals in society are practicing TM individually; we refer to this prediction as the "$\sqrt{1\%}$ hypothesis." In the case of both the 1% and $\sqrt{1\%}$ hypothesis, social stress is said to be reduced sufficiently to create a measurable improvement in trends of life in the whole society as indicated, for example, by declines in crime, violence, and accident rates, as well as improvement in other social indicators (Maharishi Mahesh Yogi, 1977, p. 110; 1986b, p. 76).

The $\sqrt{1\%}$ hypothesis (or, equivalently, the 1% hypothesis) is a nonlinear phase transition model of social change. A phase transition to a state of reduced stress and improved societal QOL is predicted to begin when a "tipping point" or critical threshold is reached—either approximately 1% of the population practicing TM individually or approximately the $\sqrt{1\%}$ practicing the TM-Sidhi program in a group in one place. Phase transitions occur commonly in nature: examples include (among many others) the transition of water when cooled sufficiently from a more unordered liquid phase to the ordered crystalline structure of ice. Another example is the emergence of superfluidity and macroscopic

coherent quantum wave behavior in liquid helium as the temperature approaches absolute zero. The concept of phase transitions offers a useful conceptual framework for understanding how a complex, more ordered structure in a system emerges from a less-ordered structure as some system parameter is varied.

2.4 How Experience of Pure Consciousness Influences Collective Consciousness

The predicted result of enlivening pure consciousness in collective consciousness through the TM and TM-Sidhi program is reduction of stress in individual and collective consciousness, leading to enhanced societal QOL (Maharishi Mahesh Yogi, 1975, p. 59). Maharishi (1975) explains that this beneficial influence propagates throughout society as a result of individuals transcending the subtlest level of thought and consciously contacting the field of pure consciousness during their practice of Transcendental Meditation:

> Because consciousness is the basis of all that is there—here, there, and everywhere—it is the quantum level of life, the very basic level of life. If the attention reaches that level, what happens is like the small pebble falling on the silent bed of the water. A small pebble falls, creating impulses. Those impulses reach all the far places and all the water. Just like that, when the conscious mind of one single individual transcends, we can imagine the thrills being created on that silent level of consciousness, which is the omnipresent reality. This pulsating consciousness of the individual creates impulses of life all over, and because this is the very fundamental level of everyone, everyone's thinking, everyone's consciousness is influenced by that. It is very easy to understand. (p. 59)

Maharishi (1975) further explains that as a result of even a small percentage of the individuals in society experiencing pure consciousness during TM enlivens pure consciousness in the collective consciousness of society, positively influencing societal trends:

> The whole society becomes more positive in its trends, more positive in its thinking. The awareness of the whole population is influenced tremendously. That is why the criminals change, negativity changes. A man thinking like that today, he thinks in a different way tomorrow. So, all the non-evolutionary procedures of thinking get transformed. Non-evolutionary thinking becomes evolutionary thinking. (p. 59)

The term “evolutionary thinking” in this context refers to thoughts that have a constructive, beneficial, life-supporting influence that leads to behavior promoting the wellbeing of both the individual and society.

Practice of the TM or the TM and TM-Sidhi program by a sufficient percentage of individuals in society is predicted to reduce societal stress and promote improved quality of life in society (Maharishi Mahesh Yogi, 1975, p. 59). The relationship between social stress and societal QOL has been investigated, for example, by Linsky and Strauss (Linsky, Bachman, & Strauss, 1995; Linsky & Strauss, 1986) who analyzed the relationship between social stress and crime rates. The social-stress perspective has the advantage of being related to the extensive literature on stress at the individual level discussed above. Using a state stress index (SSI) based on the “life-events” concept of stress to quantify community, family, and economic stressors (Holmes & Masuda, 1974), Linsky and Strauss (1986) reported a significant relationship between the SSI and rates of homicide, rape, robbery, and aggravated assault. Their analysis statistically controlled for a number of other control and moderating variables.

Also, Linsky, Bachman, and Strauss (1995) reported a significant association between higher social stress as measured by the SSI and higher homicide rates, controlling for the racial composition and urbanization levels of the states. The relation of the SSI to homicide rates was unrelated to measures of economic deprivation, weak social control, and cultural support for violent behavior. Further discussion of the relationship between the current field-theoretic perspective and other influential theories of crime is given in Cavanaugh and Dillbeck (2017a) and Dillbeck and Cavanaugh (2016).

2.5 Some Parallels from Physics

2.5.1 Field Effects in Physics

The practice of the TM and TM-Sidhi program by a small percentage of the whole population is predicted to create nonlocal effects in society that are produced independent of direct behavioral interaction between the meditators and other people in society. Such nonlocal effects in social systems exemplify a characteristic property of all fields in physics, “action at a distance.” Phenomena involving action at a distance in physics, such as the gravitational effect of the moon on the earth, are typically explained by field theories which posit the existence of a field that mediates the interaction (e.g., Sudarshan & Mukunda, 1974). If indeed consciousness is a field, effects propagated at a distance should be observed in social behavior (Dillbeck et al., 1987).

Analogous to principles of quantum field theory in physics, quantum physicist John Hagelin (1987) suggests that the predicted societal effects generated by a group practicing TM and its advanced techniques consisting of approximately the √1% of the population are "based on a field theoretic model utilizing a coherent superposition of [wave] amplitudes, in which the intensity of the effect generated is proportional to the square of the number of participants" (p. 65). Such "constructive interference," analogous to that produced by placing two loudspeakers close together, is said to generate a powerful effect in the field of pure consciousness that radiates out and positively influences the collective consciousness of the whole society.

2.5.2 Phase Transitions

As discussed above, the √1% hypothesis is based on a phase transition model. There are many examples in physical systems in which the more coherent, orderly functioning of a small proportion of the units of the system will induce a phase transition to more orderly, coherent behavior of the system as a whole. One example is laser light, which is generated by constructive interference of light waves produced by stimulated emission of photons by only small fraction of the atoms in a system. Stimulated emission induces a quantum-mechanical phase transition in the entire system, in which all the photons begin to interact coherently, producing a macroscopic quantum wave of laser light. The intensity of laser light is proportional to the square of the number of emitting elements (Gross & Haroche, 1982).

2.5.3 Physics and Consciousness

Many noted figures in modern physics have suggested that consciousness must be deeply related to the most fundamental descriptions of nature's functioning. For example, eminent physicist Sir Arthur Eddington said "the stuff of the world is mind-stuff," and Max Planck declared that "I regard consciousness as fundamental. I regard matter as derivative of consciousness" (Oates, 2020, p. 42). Likewise, Hagelin (1987, 1989), who worked closely with Maharishi for more than 30 years in analyzing the relationship of physics and consciousness, points out that the Vedic description of the field of pure consciousness features striking structural and functional parallels to the description of the unified field in supersymmetric, quantum unified field theories. MVST describes a single, unbounded, unified field of intelligence beyond space and time, inherent in which are all the laws of nature that govern the evolution of human life and the entire universe. This field of pure consciousness is said to give rise to the physical universe through a lively internal dynamics of self-interaction (Nader, 2021).

Hagelin points out that unified field theories in physics (e.g., Schwarzschild, 1985; Waldrop, 1985), like MVST, describe the unified field as an unmanifest, self-interacting field in which all natural laws, all principles of orderly change that administer everything in the universe, are inherent in a unified state. Hagelin (1987, 1989) observes that although research and debate continue about the details of unified field theories and their mathematical formulation, there is wide agreement among theorists as to the plausibility of the big picture that natural law is unified at the most fundamental level of nature's functioning (the Planck scale of spacetime).

According to Hagelin, whose papers on superstring theory are some of the most cited references in the physical sciences, the most parsimonious explanation for the striking similarity between descriptions of the unified field in quantum field theory and that in the Vedic description of pure consciousness is that these two traditions of knowledge are describing the same unified field of natural law from two different perspectives: objective and subjective (Hagelin, 1987, 1989, 2019).

The following section briefly summarizes the results of previous peer-reviewed empirical tests of the phase transition model.

3. Previous Empirical Research on Field Effects of Consciousness

3.1 Overview and Introduction

The hypothesis of field effects of consciousness has been repeatedly tested empirically at various levels of society: city, state/province, national. Because many readers may be unfamiliar with the empirical literature on this topic, the following selective review provides a more detailed discussion of individual studies than is customary. Of the 23 peer-reviewed empirical articles in independent scholarly journals, several of which contain multiple independent empirical studies, we discuss in this section those studies focusing primarily on effects on crime. For brevity, Appendix A discusses additional peer-reviewed research that analyzes outcomes concerning reduction of warfare, terrorism, and international conflict. This literature review draws heavily on Cavanaugh and Dillbeck (2017b).

For additional discussion of the empirical literature on field effects of consciousness refer to Orme-Johnson and Fergusson (2018) who provide a comprehensive review of the more than 50 published empirical studies of this

hypothesis—including those appearing in academic conference proceedings, research anthologies, book chapters, and peer-reviewed papers published in independent journals and journals devoted to research on Transcendental Meditation.

Most of the peer-reviewed empirical studies have examined the effect of the more powerful group practice of the TM and TM-Sidhi program because of the fewer number of people required to create a theoretically predicted effect—the √1% of the population practicing the TM and TM-Sidhi program together in a group rather than 1% practicing TM individually. Also, analysis of group TM and TM-Sidhi practice allows analysis of monthly or weekly data on social indicators rather than annual data; this allows research to be conducted more easily using quasi-experimental designs (Shadish, Cook, & Campbell, 2002). Many of these previous studies use Box-Tiao impact-assessment analysis (Box & Tiao, 1975; McCleary, McDowall, & Bartos, 2017) or Box-Jenkins transfer function (TF) analysis (Box & Jenkins, 1976) to model the time-dependence of the data. Other recent studies use segmented-trend regression analysis (linear-spline regression) to analyze changes in trends of social indicators (Marsh & Cormier, 2002; Mitchell, 2012).

3.2 Studies of the √1% Hypothesis Using Data from Asia, Africa, and Latin America

3.2.1 Cambodia

A recent time series study examined the effects of group practice of TM and its advanced techniques on socio-political violence in Cambodia 1990-2008 using segmented-trend regression (Fergusson & Cavanaugh, 2019). A significant reversal of a rising three-year baseline trend was found for a monthly measure of socio-political violence in war-torn Cambodia ($t(219) = –7.01$, $p < .0001$, with medium large effect size $f = –0.474$). The trend reversal (beginning in January 1993) was associated with the introduction of large group practice of these Vedic technologies of consciousness at Maharishi Vedic University (MVU) in Cambodia. This change in trend resulted in a 6.0% annual rate of reduction in violence during the experimental period 1993 to 2008. The violence measure was based on data provided by a leading commercial provider of automated content analyses of news reports (Virtual Research Associates, Inc.) that was blind to the hypotheses of the study (Bond et al., 2003). The authors conclude that the decline in violence could not plausibly be attributed to pre-existing trends, seasonal or other cycles in the data, or the activities of a UN peacekeeping mission that failed in its mission to disarm and demobilize the warring factions in the civil war.

The effect size measure f is the square root of a variant of Cohen's f^2 for multiple regression coefficients (Cohen, 1988; Darlington & Hayes, 2017, pp. 226-228; Grissom & Kim, 2012), where 0.59, 0.39, and 0.14 are typically considered large, medium, and small effects, respectively (see Appendix B).

3.2.2 Mozambique

In 1993-1994, at the request of the Government of Mozambique, more than 3000 members of the armed forces and civilians were taught the TM and TM-Sidhi program in the capital city of Maputo and other areas of the country. According to a published case study authored by Lt. Gen. Tobias Dai (2011), Commander of the Armed Forces at the time, the government recognized the following benefits from the implementation of these technologies of consciousness: peace was stabilized after 16 years of civil war; the crime rate declined unexpectedly by 20% in Maputo and other areas (and rose again when troop movements reduced the number of daily participants in the group practice); fatalities from auto accidents decreased despite increased driving; unexpected rains ended the worst drought of the century; and economic growth surprisingly surged by 19%.

3.2.3 India

A temporary group of up to 3000 participants in a course on Maharishi's Vedic Science practiced the TM and TM-Sidhi program together for five months in 1980-1981in the Union Territory of Delhi in India. During this period, the group's size consistently exceeded 245, the √1% of the population of the area. Impact-assessment analysis (Dillbeck, Cavanaugh, Glenn, Orme-Johnson, & Mittlefehlt, 1987) found that the group practice was associated with significant 11% drop in daily total crime totals (defined by the Indian Penal Code) during this period as compared with the mean daily total during a five-month baseline period ($t(260) = –5.12$, $p < .0001$, $f = –0.318$, a medium ES). The dependent variable was daily crime totals rather than rates because daily data on population changes was not available. Detailed consideration of possible confounding factors, such as policing practices, pre-existing trends, or seasonal patterns, did not reveal any plausible alternative explanations that could account for the magnitude of the observed decline in crime.

3.2.4 The Philippines

For five and one-half months in 1984-1985, an international delegation of up to 1500 TM teachers practiced the TM and TM-Sidhi program together in groups whose combined influence exceeded the required √1% threshold for the 8 million population of the Metro Manila area. The participants came to the Philippines due to demand for TM instruction in education and rehabilitation settings, and they taught TM to several thousand individuals in Metro Manila and other

areas during this period. TS impact-assessment analysis (Dillbeck et al., 1987) reported a significant 12.1% reduction in the weekly index of crime totals in Metro Manila (similar to the FBI Uniform Crime Index in the U.S.) ($t(93) = -2.83$, $p < .005$ one-tailed, $f = -0.293$). The drop in crime was relative to the mean of the pre-experimental baseline period of the study consisting of the weeks beginning December 31, 1982, through mid-August 1984. There were no changes in laws, police reporting, or policing practices, or other events that could account for the reduction in crime; nor could the results be explained by trends or seasonal and other cycles in the data.

3.2.5 Puerto Rico

There was a significant reduction in the monthly crime rate in Puerto Rico in April 1984 ($t(160) = -2.02$, $p < .025$ one-tailed, $f = -0.160$) after establishment of a temporary group practicing the TM and TM-Sidhi program together whose size approximately equaled the √1% threshold for the population of Puerto Rico (185 participants). An increase in crime was observed in July 1984 with the departure of the group (Dillbeck et al., 1987). The group was located in the city of Fajardo, 68 miles from the capital San Juan. The monthly crime rate measured Type 1 crimes (comparable to the FBI Uniform Crime Index), and the data was analyzed using impact-assessment methods. No viable alternative explanation based on policing levels or methods or other factors could be identified by the authors.

3.3 Studies of U.S. Cities with 1% of the Population Practicing TM

The earliest studies of the 1% hypothesis were of crime rates in a sample of cities, controlling for changes in demographic variables usually used to predict crime. For example, in 24 experimental cities that reached 1% of their population instructed in TM, and controlling statistically for eight demographic variables, there was a significant decline in crime rate the next year ($F(1,44) = 13.77$, $p < .001$, with effect size $f = 0.559$) and a significant reduction in crime rate trend over five years ($F(1,44) = 5.71$, $p < .025$, $f = 0.360$) (Dillbeck, Landrith, & Orme-Johnson, 1981). As in almost all cases for these early studies in the 1980s, the statistical test of the predicted effect was one-tailed because the direction of effect was predicted by theory.

Other studies of the 1% hypothesis used causal modeling (cross-lagged panel analysis) of random samples of 160 U.S. cities and 80 U.S. Standard Metropolitan Statistical Areas to confirm that TM was the causal agent in the observed crime rate decrease. This analysis controlled respectively for 10 and 13 demographic variables related to crime rate. Participation in the TM program predicted a decreased crime rate, while the reverse was not true (Dillbeck, Banus, Polanzi, & Landrith, 1988).

3.4 Studies of the √1% Hypothesis Using Data from the U.K. and U.S.

3.4.1 U.K. √1% Research

When a group of TM-Sidhi participants adjacent to Merseyside, U.K., in March 1988 grew sufficiently in size to theoretically affect the whole Merseyside metropolitan area, a decrease in crime was observed in the area, a finding unique to Merseyside at that time (Hatchard et al., 1996). Impact-assessment analysis of data from 1979 to 1991 reported a significant 13.4% reduction in crime rate ($t(141) = -4.68$, $p < 0.0001$, $f = -0.394$) beginning in March 1988, a reduction independent of economic trends.

3.4.2 U.S. Studies of the √1% Hypothesis

In the early 1980s, the group of TM-Sidhi program participants at Maharishi International University (MIU) reached the required number of approximately the √1% for the USA. MIU is a non-profit institution regionally accredited by the Higher Learning Commission with its main campus in Fairfield, Iowa. Using impact-assessment and TF methods, Dillbeck (1990) found a significant reduction in fatalities due to homicide, suicide, and motor vehicle fatalities during 1982-1985 when the size of the group reached the √1% of the population ($t(136) = -2.47$, $p < 0.01$, $f = -0.212$). TF results indicated that although the size of the group temporally led changes in violence, the reverse was not true.

Two other U.S. studies reported reduced violent crime in Washington, D.C. (Dillbeck et al., 1988; Hagelin et al., 1999) during periods when there were large groups of TM-Sidhi program participants established in the metropolitan area. In the former study, significant reductions were reported in all FBI violent crimes, $t(100) = -2.52$, $p < 0.05$, with ES $f = -0.252$. Both studies used TF analysis because the group size was more than the predicted threshold.

The 1999 study used a much larger group size and looked at, in particular, violent crimes against persons (homicide, rapes, and assaults), $t(39) = -5.47$, $p < 0.0001$, $f = -0.876$. This $6 million prospective "National Demonstration Project," held from June 7 to July 30, 1993, was one of the largest sociological experiments ever conducted. The prediction of a 20% decline in violent crime was lodged in advance with the national and international press and with an independent project review board. The 24-member review board—composed of social scientists, government leaders, and members of the city police department—approved the detailed research protocol and gave feedback on

the final project report, which was co-authored by a member of the police department. D.C. crime dropped steadily as the group size increased, and by the end of the project when the size of the meditation group was maximum (approximately 4000) violent crime dropped by 23%.

The use of visiting experts in the TM-Sidhi program for Manila (Dillbeck et al., 1987) and Washington, D.C. (Hagelin et al., 1999) demonstrates that any group large enough for the effect is sufficient**,** whether or not the participants are local citizens.

3.4.3 Prior Research on the Current U.S. Social Experiment

Outcomes of the 15-year quasi-experiment analyzed in the current study have been empirically analyzed in four previous peer-reviewed papers. Using segmented-trend (linear-spline) regression modeling, these four papers investigated changes in monthly trends of homicide rates and trends in other fatality rates during 2007-2010 as compared with a baseline period November 2002-December 2006. Reported results include reduced trends in U.S. homicide rates, $t(84) = –10.17$, $p < 0.001$, $f = –1.11$; reduced murder and violent crime rate trends in large urban areas, $t(83) = –6.14$, $p < 0.001$, $f = –0.674$ (Dillbeck & Cavanaugh, 2016; Cavanaugh & Dillbeck, 2017a); reduced trend of motor vehicle fatality rates, $t(87) = –8.55$, $p < 0.001$, $f = –0.917$ and fatality rates due to other accidents, $t(86) = –3.82$, $p < 0.001$, $f = –0.412$ (Cavanaugh & Dillbeck, 2017b); and reduction of trend in rates of drug-related fatalities, $t(86) = –4.16$, $p < 0.001$, $f = –0.449$ and U.S. infant mortality, $t(87) = –4.50$, $p < 0.001$, $f = –0.482$ (Dillbeck & Cavanaugh, 2017). Moreover, a pilot study using annual data replicated the reduction of homicide-rate trends during the experimental period and also found that homicide-rate trends rose again when the size of the meditation group fell (Orme-Johnson, 2017; Orme-Johnson et al., in review).

3.5 Current Study

The current study differs from the previous research on homicide rates discussed above (Dillbeck & Cavanaugh, 2016; Cavanaugh & Dillbeck, 2017a). First, we use an expanded data sample consisting of 12 months of additional data for both the experimental and baseline periods. January 2002 was selected as the initial month of the baseline in order to avoid bias due to the extremely large homicide totals associated with the 9/11 incident of September 2001. Second, in order to test the hypothesis of an increase in homicide trend during the post-experimental phase we examine homicide trends during a 60-month post-experimental period when the group at MIU substantially decreased in size. Also, we discuss new sensitivity analyses, explore additional alternative possible explanations for the results, and consider possible physiological mechanisms that may mediate the postulated field effects of consciousness.

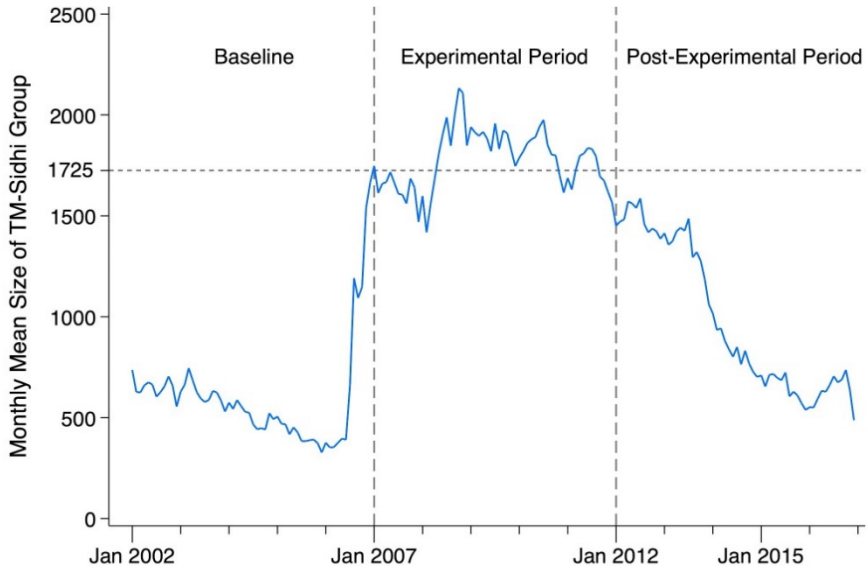
4. Data and Method

4.1 Prospective Social Experiment

Like previous research on this social experiment, we define the baseline, experimental, and post-experimental periods in terms of the number of participants in the group practice of the TM and TM-Sidhi program at MIU (the "TM-Sidhi group" or, alternatively, "the group"). The group is composed of students, faculty, staff, and other community members who gather to practice these technologies of consciousness together twice daily, before and after the school or work day. We use the monthly mean number of daily participants in the afternoon group meditation session to define the baseline, experimental, and post-experimental periods of the study.

As shown in Figure 1a, as of mid-summer 2006, mean monthly participation in the TM-Sidhi group had displayed a declining trend for more than three years. In July 2006 university leaders initiated an effort to substantially increase the size of the group from an average of less than 400 in June 2006 to approximately the √1% of the U.S. population—1725 group participants, based on the 297 million U.S. population at that time. TM-Sidhi practitioners from around the U.S. and abroad were invited to participate in a special program to expand the size of the group. To further increase the size of the TM-Sidhi group, starting in October 2006, visiting TM-Sidhi experts from India joined the group. The initiative to increase the size of the MIU group was supported by a grant to MIU from the Howard and Alice Settle Foundation.

(a)



(b)

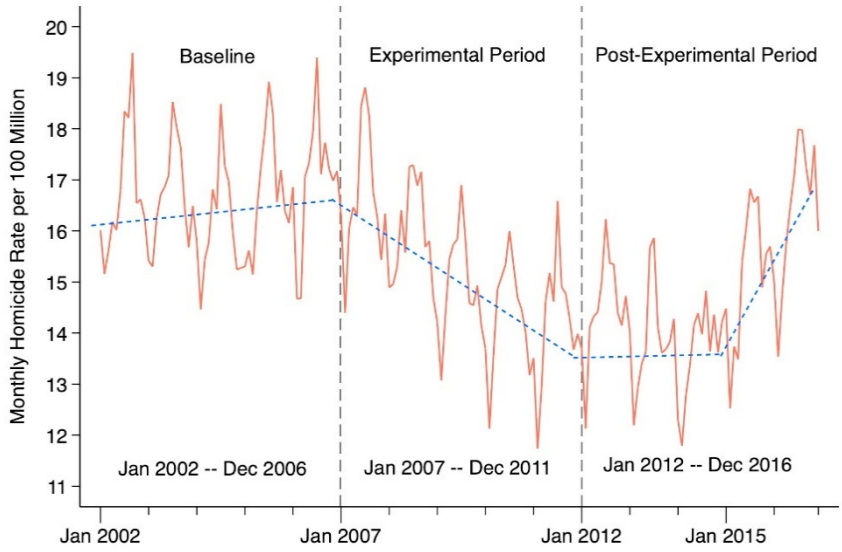


Figure 1. Panel (a): Monthly mean number of individuals practicing the Transcendental Meditation and TM-Sidhi program together in a group at Maharishi International University, Fairfield, Iowa, 2002-2016. Panel (b): Monthly U.S. homicide rate per 100 million people (mean daily rate per month) 2002-2016 with fitted linear-spline trend segments (seasonally adjusted).

At the outset of the prospective quasi-experiment, based on previously published theoretical principles and empirical research, press releases and other publicity predicted that reductions in rates of homicide and violent crime would be a measurable impact of the group when the size of the group reached approximately the √1% level.

4.2 Experimental and Baseline Periods

In January 2007 the mean monthly size of the TM-Sidhi group first reached the predicted, approximate critical threshold and remained above or near this level through 2011 (see horizontal dotted line in Figure 1a). The group

remained above or near the threshold during 2007 (averaging 1636 for the year, or 95% of the 1725 threshold). Although somewhat below threshold for the first four months of 2008, the average monthly size of the TM-Sidhi group for the year was 1824.

For the five years January 2007 through December 2011, the annual mean monthly size of the group was 1815 (105% of the threshold). Thus, we define the five years 2007-2011 as the experimental period (the years between the two vertical dashed lines in Figure 1a) during which the average size of the group exceeded approximately the √1% of the U.S. population and averaged at least 95% of the approximate √1% threshold for each of the five years. The period January 2002 to December 2006 serves as the baseline period.

We define January 2012 through December 2016 as the post-experimental period, during which, due to reduced funding, group participation declined substantially. Average annual monthly group participation fell to 1448 in 2012, declined further to 1338 in 2013, declining sharply to 837 in 2014, and then to 654 in 2015 and 628 in 2016.

December 2011 was selected as the end point for the experimental period. In that month the size of the group fell from above threshold to 91% (1566) of the approximate threshold of 1725. A possible alternative choice for an end point is September 2011 when the group size for the month declined from above threshold to 98% of threshold (1694), never again to exceed 1725 in the sample period. The sensitivity analysis reported below (see Section 5.5) explores the empirical implications of this choice of endpoint.

The choice of December, rather than September, reflects previous research (e.g., Hagelin et al., 1999) that suggests a relatively slow decay in the impact of a TM-Sidhi group may be expected when the group size declines after being above threshold for an extended period. Also, as noted above, the mean size of the group remained relatively large in 2012 and 2013, declining more sharply to levels near those of the baseline period by the end of 2014. Theoretical considerations suggest that as the group declines, societal stress may be expected to build up again in collective consciousness, gradually eroding the gains of the experimental period. Eventually a point will be reached when social stress begins to rise sufficiently in collective consciousness to begin to reverse the improvement in trends of societal QOL generated during the experimental period. Thus, the specification of a December trend-break, or "spline knot," was based on the hypothesized carryover effect, or gradual decay in the hypothesized societal impact of the group after its size had fallen below the approximate predicted threshold.

In social science the precise timing and form of such dynamic effects in interrupted time series (ITS) research such as the current study are almost always empirically determined (e.g., see Box & Tiao, 1975; McLeary et al., 2017). In any event, as discussed in the sensitivity analyses reported below, re-analysis of the data using September 2011 as the final month of the experimental period did not materially alter the conclusions of the current study.

A further sensitivity analysis considers an alternative scenario in which the onset of the experimental period is delayed until May 2008 while retaining December 2011 as the final experimental month. In May 2008, the average size of the group rose above 1700 and (except for three months, December 2010-February 2011) remained there continuously for 40 months until August 2011. Re-analysis of the data using May 2008 as the first experimental-period month does not alter the conclusions for the two research hypotheses of the study.

4.3 Data Definitions and Sources

Data definitions and sources are described in Appendix C below. Monthly homicide totals for January 2002 through December 2016 were obtained from the U.S. Centers for Disease Control (CDC). When the current analysis was completed, monthly homicide data for 2016 were the most recent available. The daily number of group participants in the afternoon meditation session at MIU was provided by the MIU Department of Development of Consciousness and converted into monthly averages. The dependent variable is the monthly U.S. homicide rate (monthly mean daily rate per one million).

4.4 Research Hypotheses

The current analysis tests two research hypotheses. Hypothesis 1 predicts a significant reduction in trend slope, relative to the five-year baseline trend, for the U.S. monthly homicide rate (*homr*). The trend reduction was predicted to begin with onset of the five-year experimental period (January 2007 to December 2011). We evaluate Hypothesis 1 by estimating a segmented-trend regression model for *homr* (Marsh & Cormier, 2002; Mitchell, 2012). As shown in Figure 1b and discussed below (Section 4.6), the model includes joined linear trend segments for the pre-experimental, experimental, and post-experimental periods. These connected trend segments are known as a linear spline. The homicide rate shows strong seasonal variation around the fitted linear trend segments, with the rate highest during warmer summer months.

Hypothesis 2 predicts an increase in the homicide trend slope (relative to the experimental-period trend) during the post-experimental subperiod 2012-2016, when the number of group participants fell substantially below the approximate √1% threshold.

The general pattern of TS behavior for *homr* displayed in Figure 1b appears to be broadly consistent with both research hypotheses. During the baseline period, *homr* shows a gently rising (but not statistically significant) baseline trend that shifts to a declining trend in the experimental period. Likewise, consistent with Hypothesis 2, during the first post-experimental subperiod (January 2012-December 2014), the *homr* trend flattens out, displaying an increase in trend slope relative to that in the experimental phase. During the second post-experimental subperiod (January 2015-December 2016), a further increase in trend is apparent for *homr* when the average monthly size of the meditation group bottoms out and reaches low levels similar to the baseline period.

4.5 Interrupted Time Series Research Design

The previous studies reviewed in Section 3 that investigate the 1% and √1% effect using impact-assessment and segmented-trend regression modeling are examples of interrupted time series analysis. When randomized, controlled experiments are not feasible, ITS quasi-experimental designs are appropriate for the analysis of the longitudinal impacts of events in social systems, such as new programs, policy changes, or laws, (Cook & Campbell, 1979; Glass, 1997; Shadish et al., 2002). Such prospective quasi-experimental designs are inherently stronger than ex-post analyses of archival data (Glass, 1997).

ITS designs are considered to be appropriate designs for causal inferences in such social experiments (Glass, 1997; Shadish et al., 2002) even in the absence of a comparison group (1) because of their control over regression to the mean and (2) because the TS behavior of the outcome variable prior to introduction of the program can be used to specify an empirically based "counterfactual" for calculation of treatment effects (Linden, 2015). ITS analysis has been widely applied in many areas of the social and other sciences, including, for example, evaluation of approaches to reducing criminal violence (e.g., Dugan, 2010).

When dependent variables display highly nonlinear behavior (such as that shown by *homr* in Figure 1b) and when research questions focus on impacts on trends, linear-spline regression models are useful ITS models for estimating quasi-experimental impacts (Marsh & Cormier, 2002; Mitchell, 2012). Linear-spline models have been widely used, for example, in analyzing the impacts of gun laws on violent crime trends (e.g., Durlauf, Navarro, & Rivers, 2016; Lott & Mustard, 1997). By contrast, impact-assessment and transfer function ITS methods (Box & Jenkins, 1976; Box & Tiao, 1975; McCleary et al., 2017) often require differencing of the dependent variable, which removes any trends in the data.

4.6 Segmented-Trend Regression Model

The regression model in the current study differs from the linear-spline model used in previous studies of homicide rates during this social experiment (Dillbeck & Cavanaugh, 2016; Cavanaugh & Dillbeck, 2017a); two trend segments were added in order to model five years of monthly post-experimental data that were not available at the time of the earlier research. The nonlinear changes in trend for *homr* were assessed using a model consisting of four joined linear trend segments: a baseline period (January 2002-December 2006), experimental period (January 2007-December 2011), and a post-experimental period with two subperiods (January 2012-December 2014 and January 2015-December 2016).

In addition to a random error term, the model given in Equation 1 below also includes a deterministic seasonal component to model monthly seasonal variation around trend segments.

The segmented-trend model is given by the following expression

$$y_t = \beta_0 + \beta_1 T_t + \beta_2 I_{1t}(T_t - 59) + \beta_3 I_{2t}(T_t - 119) + \beta_4 I_{3t}(T_t - 155) + \text{seasonal component} + \varepsilon_t, \quad T_t = 0, 1, 2, \ldots, 179. \tag{1}$$

In Equation 1, y_t is the dependent variable, the monthly homicide rate *homr*. β_0 is the intercept at time $T_t = 0$ (January 2002). T_t is a monthly time counter used to estimate the baseline time trend beginning January 2002. β_1 is the baseline trend slope. The change in trend slope for the experimental period is given by the coefficient β_2 for the interaction term $I_{1t}(T_t - 59)$. I_{1t} is a binary indicator variable that equals zero prior to December 2006 and equals 1 thereafter. The interaction defines a monthly time counter for the experimental-period time trend, where $I_{1t}(T_t - 59) = 1, 2, 3, \ldots, 120$ starting January 2007 and the interaction is zero prior to that month. Because the time counter starts at $T_t = 0$, the number 59 in the interaction term represents the 60th month of the baseline (December 2006), the month of the first

trend break ("spline knot"). Hypothesis 1 predicts that β_2 should have negative sign, indicating a reduction in trend slope.

Similarly, β_3 quantifies the change in slope beginning with the onset of the post-experimental period in January 2012. I_{2t} is a binary indicator variable that equals zero prior to December 2011 and equals 1 thereafter. The time counter for the linear trend segment 2012-2014 is $I_{2t}(T_t - 119) = 1, 2, 3, \ldots, 60$ beginning January 2012 and equal to zero before that month. If β_3 has positive sign, indicating an increase in trend slope, this would offer support for Hypothesis 2.

Likewise, β_4 gives the change in trend slope for the trend segment January 2015-December 2016. The interaction term defines a monthly time counter for this trend segment, where $I_{3t}(T_t - 155) = 1, 2, 3, \ldots, 24$ starting January 2015 and is zero prior to that month.

Due to the "change-in-slope coding" of spline segments (Mitchell, 2012, p. 88), the slope for each trend segment two to four is given by the slope for the previous segment plus the change in slope from the previous segment. Therefore, the trend slope during 2002-2006 is β_1, the 2007-2011 trend slope is $\beta_1 + \beta_2$, the slope for 2012-2014 is $\beta_1 + \beta_2 + \beta_3$, and the slope for the 2015-2016 segment is $\beta_1 + \beta_2 + \beta_3 + \beta_4$. Thus, the change of slope for 2015-2016 relative to the experimental-period trend is $\beta_3 + \beta_4$. A positive estimate for this sum would also be consistent with Hypothesis 2.

The seasonal component models the seasonal variation in *homr*, thus providing seasonally adjusted estimates for the other regression coefficients. Standard binary (0/1) seasonal indicator variables were created for each month, with the indicator taking the value one for each month and zero otherwise. To create centered seasonal coefficients that sum to zero for each year, $1/m$ was subtracted from each monthly indicator variable, where $m = 12$ is the number of annual seasonal periods (Doornik & Hendry, 2013, p. 19). For each year, the centered monthly seasonal effect for that year is given by the regression coefficient S_k for months $k = 1, 2, \ldots, 12$. When estimating Equation 1, the seasonal indicator variable for December was omitted to avoid exact linear dependence.

The constant term for Equation 1 is $\beta_0 + S_k$; thus the vertical position of the baseline trend and the other joined line segments connected to it is shifted higher or lower at every point (parallel) depending on the specific month *k.* For illustrative purposes, the connected line segments in Figure 1b were derived using the seasonal coefficient for January.

Finally, the regression error term ε_t is an independent and identically distributed, serially uncorrelated normal "white noise" process with mean zero and variance σ^2.

Note that the 2015-2016 post-experimental subperiod trend segment was an empirically based addition to Equation 1 in order to better model the 2015-2016 nonlinear increase in *homr* trend that is associated with the decline in the size of the TM-Sidhi group (see Figures 1a and 1b). The addition of the 2015-2016 segment was necessary to yield satisfactory results of diagnostic tests of residuals for the full estimated regression model.

4.7 Model Estimation

We estimated Equation 1 using ordinary least squares (OLS) with standard errors (SEs) and *t*-ratios corrected for possible violation of OLS statistical assumptions in TS regression analysis. These robust SEs correct for heteroskedasticity (non-constant variance) of regression residuals that can invalidate statistical tests for regression coefficients. The robust SEs also adjust for positive serial correlation of regression residuals that can downwardly bias SEs for regression coefficients, thereby inflating their *t*-statistics. Thus, Table 1 reports *t*-ratios for the OLS coefficients based on SEs that are "heteroskedasticity-and-autocorrelation-consistent" (HAC). The HAC SEs remain valid (consistent) in the case of autocorrelation and/or heteroskedasticity of possibly unknown form (Newey & West, 1987).

Table 1. OLS Regression Estimates for Homicide Rate (*homr*)

Regression Coefficient	Coeffic. Estimate	Standard Error (SE) [1]	$t(163)$ [2]
Trend 2000-2006 (β_1)	.006	.005	1.09
Trend Shift 2007 (β_2)	–.054	.009	–6.08[a]
Trend Shift 2012 (β_3)	.050	.012	4.10[a]
Trend Shift 2015 (β_4)	.131	.025	5.34[a]
Constant Term (β_0)	16.454	.214	76.78[a]
January seasonal (S_1)	–.428	.176	–2.44[d]
February seasonal (S_2)	–1.619	.184	–8.82[a]
March seasonal (S_3)	–.695	.184	–3.78[b]
April seasonal (S_4)	.143	.193	.74
May seasonal (S_5)	.537	.186	2.89[c]
June seasonal (S_6)	1.178	.163	7.24[a]
July seasonal (S_7)	2.123	.185	11.47[a]
August seasonal (S_8)	1.376	.193	7.13[a]
Sept seasonal (S_9)	.797	.187	4.27[a]
Oct seasonal (S_{10})	.281	.182	1.54
Nov seasonal (S_{11})	.071	.174	.41
Outlier Sept 2002	2.504	.547	4.58[a]
F-statistic: $F(16,163) = 52.30$ ($p < .0001$)		Mean (SD) of *homr* = 15.546 (1.600)	
Root MSE = 0.542		$R^2 = .885$; Adjusted $R^2 = .873$	
Sum of squared residuals = 52.821		Log-likelihood = –145.065	

Note: Sample is January 2002-December 2016, $N = 180$. OLS = ordinary least squares. HAC = heteroskedasticity and autocorrelation consistent. LM = Lagrange multiplier. 1. HAC SEs (Newey-West) with automatic bandwidth selection of 23 lags. 2. HAC t-ratios ($df = 163$). t-ratios are those reported by Stata and may differ from the coefficient estimate divided by SE due to rounding in the table. Two tailed p-values: a. $p < .0001$, b. $p < .001$, c. $p < .01$, d. $p < .05$

5. Results

5.1 Estimated Regression Model

Tables 1 and 2 provide full details of the regression results for Equation 1. We performed the regression analysis using Stata 16.1 (StataCorp, 2019). The HLM test for stationarity of regression residuals was calculated using Time Series Modelling 4.51 software (Davidson, 2019).

Table 2. Regression Diagnostics for Regression Results Reported in Table 1

LM test for no serial correlation[1]:	LM test for no heteroscedasticity[2]:
Lags 1-12: $\chi^2(12) = 31.433$ ($p = 0.002$)	$\chi^2(16) = 17.480$ ($p = 0.356$)
LM test for normality[3]:	LM test for no ARCH[4]:
$\chi^2(2) = 1.672$ ($p = 0.433$)	Lags 1-6: $\chi^2(6) = 5.885$ ($p = 0.436$)
HML test for stationarity[5]:	Test for linear functional form[6]:
$Z = –1.544$ ($p = 0.939$)	$F(3,160) = 1.410$ ($p = 0.242$)

Note: Sample is January 2002-December 2016, $N = 180$. LM = Lagrange multiplier. 1. Breusch-Godfrey test for no autocorrelation of OLS residuals. 2. Breusch-Pagan test for no heteroskedasticity of OLS residuals. 3. Jarque-Bera test for normality of OLS residuals. 4. Engle's test for autoregressive conditional heteroskedasticity (ARCH). 5. Standard normal $N(0, 1)$ test statistic under null hypothesis of stationarity of OLS residuals (Harris et al., 2008). 6. Ramsey's RESET test for linearity of functional form. The p-values are two-tailed.

The model tracks the data well, as shown by the adjusted R-squared, explaining 87.3% of the variance in homicide rates. The seasonal variation suggested by the TS plot for *homr* in Figure 1b is confirmed by rejection of the null hypothesis that the seasonal regression coefficients are jointly equal to zero ($\chi^2(11) = 606.47$, $p < .0001$).

All *t*-ratios in Table 1 are based on robust HAC SEs for the OLS estimates of regression coefficients. The bandwidth of 23 lags for calculation of HAC SEs, which specifies the maximum autocorrelation lag for the adjustment of SEs, was selected automatically using the Newey-West "plug-in" procedure as implemented in the Stata add-in package ivreg210 (Baum, Schaffer, & Stillman, 2003; Newey & West, 1994). Sensitivity analysis indicates that the principal conclusions of the regression analysis are not sensitive to the selected bandwidth.

Table 2 reports diagnostic tests to assess whether key assumptions of the statistical analysis are satisfied. As discussed below (Section 5.4), all diagnostic tests are satisfactory, supporting statistical conclusion validity.

5.2 Tests of Research Hypotheses

Although Hypotheses 1 and 2 are directional, to be conservative, all tests of regression coefficients are two tailed. Consistent with Hypothesis 1, the estimate of β_2, the change in slope for *homr* beginning in January 2007, has the predicted negative sign. Also, the null hypothesis of no change in trend ($\beta_2 = 0$) is strongly rejected ($t(163) = -6.08$, $p < .0001$) with ES $f = -0.476$, a medium-large effect. This finding is consistent with the reduction in trend for *homr* during the shorter four-year experimental period 2007-2010 that was examined in previous research (Dillbeck & Cavanaugh, 2016; Cavanaugh & Dillbeck, 2017a). The 95% CI for β_2 is [–.071, –.036]. The reduction in *homr* trend during 2007-2011 reverses a slightly positive baseline trend for which the null hypothesis of zero trend slope was not rejected.

Table 1 also offers strong empirical support for Hypothesis 2, which predicts a positive post-experimental change in slope relative to the experimental period trend for *homr*. The estimate of β_3 is positive, and the null hypothesis of no change in trend ($\beta_3 = 0$**)** during the first post-experimental subperiod (2012-2014) was strongly rejected ($t(163) = 4.10$, $p < .0001$) with ES $f = 0.321$, a medium effect. The 95% CI for the estimate of β_3 is [.026, .074].

Further support for Hypothesis 2 is indicated by the positive change in slope for the 2015-2016 trend segment relative to the experimental-period trend. As described previously (Section 4.6), this difference in slope is given by $\beta_3 + \beta_4$, the 2015-2016 slope minus the experimental period slope. Consistent with Hypothesis 2, the estimated sum of coefficients is positive (.181) and significant ($t(163) = 10.06$, $p < .0001$) with ES $f = 0.788$, a large effect, and 95% CI [.146, .216].

5.3 Practical Significance: Estimated Treatment Effects

The practical, or substantive, significance of the test results for Hypotheses 1 and 2 is indicated by the medium-large, medium, and large ES for β_2, β_3, and $\beta_3 + \beta_4$, respectively. For Hypothesis 1, practical significance is also supported by the estimated ITS treatment effect (TE) for this social experiment as well as by the projected percent reduction in *homr* during the experimental period. The TE is calculated by subtracting the regression model's predicted trend value for the counterfactual homicide trend in December 2011 (the rate that would have been observed in the final month of the experimental period if the baseline trend had continued) from the actual December 2011 value of the *homr* trend. Thus, geometrically, the TE is the vertical distance between the two regression trend lines for *homr* in December 2011.

This definition of the TE is a conventional measure in ITS studies of the total impact of quasi-experimental treatment (e.g., Linden, 2015). The TE is calculated from the OLS parameter estimate for β_2 reported in Table 1, which quantifies the increase each month in the vertical difference between the observed and counterfactual homicide trends. Thus, in the final month of the 60-month experimental period (December 2011) the TE is given by $60(\beta_2)$. Appendix D provides a mathematical derivation of the TE.

Hypothesis 1 implies that β_2 should have negative sign, and thus the TE should also be negative. This hypothesis is supported by the estimated value TE = –3.220, with 95% CI [–4.259, –2.182]. Because the TE is β_2 multiplied by a known constant, its *p*-value, *t*-ratio, and ES are the same as those for the estimate of β_2 in Table 1.

An estimate of the percent reduction in *homr* during the experimental period is given by dividing the TE by the baseline (2002-2006) mean for *homr* (16.283). By this measure *homr* was reduced by 19.3% (or 3.86% average per year) during the five-year experimental period relative to the baseline mean homicide rate.

5.4 Diagnostic Tests

Table 2 reports diagnostic tests to assess whether the assumptions of the regression analysis are satisfied. Prior to correction for autocorrelation, as shown in Table 2 the null hypothesis of no autocorrelation of residuals at lags 1-12 was rejected by the Lagrange multiplier (LM) test (Breusch, 1978). This indicates that there was significant serial

correlation in the residuals and thus robust HAC SEs should be used for evaluating statistical significance of parameter estimates. Using the HAC covariance matrix of the estimated model parameters, the recalculation of the LM test for serial correlation fails to reject the null hypothesis of no serial correlation at lags 1-12 ($F(12, 63) = 0.507$, $p = .908$). This indicates that the statistical correction for autocorrelation was successful.

Valid statistical inference in TS regression requires stationarity of the regression errors (Banerjee et al., 1993; Pickup, 2015, p. 29). A TS is defined to be covariance stationary (or weakly stationary) if its mean, variance, and autocorrelations are invariant with respect to time origin (Pickup, 2015). The relevant condition is covariance stationarity of the dependent variable conditional on the regressors—that is, stationarity of the regression errors, not stationarity of the dependent variable itself (Pickup, 2015, p. 24).

A formal test for covariance stationarity that is appropriate for regression residuals is reported in Table 2: the Harris-McCabe-Leybourne (HML) test (Davidson, 2019, p. 55; Harris, McCabe, & Leybourne, 2008). Under the null hypothesis of stationarity, the HML test statistic is distributed as standard Normal $N(0,1)$ in large samples (Harris et al., 2008). We calculated the HML test using Time Series Modelling 4.51 software (Davidson, 2019) with the default settings ($c = 1.0$, $L = 0.66$). The null hypothesis of covariance stationary regression errors was not rejected ($p = 0.939$) (see Table 2), supporting the conclusion that *homr* is "segmented-trend stationary," exhibiting weakly stationary fluctuations around a segmented trend. Thus, the regression findings in Table 1 cannot be attributed to "spurious regression" due to nonstationarity (Granger & Newbold, 1986).

Stationarity of the residuals for the *homr* regression was further supported by the KPSS test for stationarity (test statistic = 0.045, $p = 0.910$) (Davidson, 2019, p. 55; Kwiatkowski, Phillips, Schmidt, & Shin, 1992). The HML test has been shown to be more powerful than the KPSS test (Choi, 2015, pp. 126-127).

As shown in Table 2, the results of all other diagnostic tests for model adequacy are also satisfactory. The null hypothesis of no heteroskedasticity of the OLS residuals was not rejected ($p = 0.356$) (Breusch & Pagan, 1979). Ramsey's RESET test fails to reject the null hypothesis of linear functional form of the estimated regression equation (Ramsey, 1969) ($p = 0.242$). Likewise, the null hypothesis cannot be rejected that the regression errors are drawn from a normal distribution ($p = 0.433$) (Jarque & Bera, 1987). The null hypothesis of no autoregressive conditional heteroscedasticity of residuals also was not rejected ($p = 0.436$) (Engle, 1982).

5.5 Sensitivity Analyses

For brevity, the details of the sensitivity analyses discussed in this section, including Tables 3-8 reporting the complete regression results, are posted online at the OSF repository (https://osf.io/2yagh/).

5.5.1 Impact of Outliers

The estimated model reported in Table 1 includes a binary indicator variable to model a single positive outlier in the data for September 2002 (here defined as a studentized, or "jackknife," residual > 3.5). As shown in Table 3 of the online supplemental files (https://osf.io/2yagh/), the results of the re-estimation of Equation 1 without adjustment for this additive outlier are very close to those presented in Table 1 and offer continued support for both Hypotheses 1 and 2 (both $p < .0001$). Likewise, all diagnostic tests for the regression are satisfactory (see Table 4 in the online supplemental files https://osf.io/2yagh/).

5.5.2 Earlier End of Experimental Period

Sensitivity analysis also considered the impact of specifying an earlier end to the experimental period. Re-estimation of Equation 1 using September 2011, rather than December 2011, as the final month of the experimental period yields substantially the same conclusions for research Hypotheses 1 and 2 as those based on Table 1 (both $p < .0001$), although effect sizes are slightly smaller. Likewise, all diagnostics remain satisfactory (see Tables 5 and 6 in the online supplemental files https://osf.io/2yagh/).

5.5.3 Effect of Delayed Onset of Experimental Period

Sensitivity analysis also examined the impact of changing the initial month of the experimental period to May 2008, when the size of the group rose above 1700 and remained there for 40 months (except December 2010-February 2011). This change also did not materially affect the conclusions for either research hypothesis ($p < .001$ and $p < .002$, respectively), although effect sizes were somewhat smaller (see Tables 7 and 8 in the online supplemental files https://osf.io/2yagh/). Thus, the conclusions of tests for both research hypotheses are not sensitive to choice of ending month or starting month for the experimental period.

6. Discussion

The findings reported in Tables 1 and 2 offer empirical support for both research hypotheses of the current study. Consistent with the prediction of Hypothesis 1, the U.S. monthly homicide rate showed a statistically significant ($p < .0001$) and substantively important reduction in trend during the experimental period 2007-2011 relative to its five-year baseline trend. This finding for the 2007-2011 experimental period replicates the findings of a significant 2007-2010 experimental-period decline in trend for homicide found in previous research (Dillbeck & Cavanaugh, 2016; Cavanaugh & Dillbeck, 2017a).

Also, consistent with Hypothesis 2, this reduction in homicide trend during the experimental period was followed by a significant increase in trend during the immediately subsequent 2012-2014 post-experimental subperiod ($p < .001$). Lending further empirical support to Hypothesis 2 is the significant, positive change in the 2015-2016 post-experimental subperiod slope relative to the experimental period trend ($p < .0001$). Diagnostic tests in Table 2 for the estimated segmented-trend regression model are all satisfactory, supporting statistical conclusion validity.

Similar findings were obtained in a preliminary analysis of data from this social experiment for three additional monthly U.S. fatality rates (in preparation). Using segmented-trend regression, the same ITS design, and 2002-2016 data sample, significant support for a reduction in trend during the 2007-2011 experimental period was found for the drug-related mortality rate ($p <.0001$, $f = .511$), motor vehicle fatality rate ($p = .0024$, $f = .241$), and fatality rate for other accidents ($p <.0001$, $f = .329$). Each variable also displayed a significant increase in trend during the post-experimental phase (all p's < .0001, with medium to large effect sizes).

The results for the homicide rate in the current study are also consistent with the findings of the analysis of annual data from the same prospective quasi-experiment. Significant reductions in trend during the experimental period 2007-2011 relative to the 2000-2006 baseline trend were found, with large ES, for rates of murder, robbery, rape, and assault, as well as fatality rates due to motor vehicle accidents, infant mortality, child accidental deaths, and drug-related fatalities (p's < .0001). In each case, the null hypothesis of no increase in trend for the post-experimental period 2012-2016 was also rejected ($p < .0001$) (Orme-Johnson, Cavanaugh, Dillbeck, & Goodman, in review).

6.1 Possible Alternative Explanations

When randomized, controlled experiments are not feasible, ITS designs, such as that in the current study, are considered to be appropriate designs for quasi-experimental research (Glass, 1997; Shadish et al., 2002). A limitation common to all such designs is the threat to internal validity posed by lack of randomized assignment to treatment conditions and the resulting risk of possible omitted variables. Rejection of the null hypothesis of no change in homicide trend during the experimental period in favor of the alternative of a decrease in trend does not itself necessarily imply that the TM-Sidhi group contributed to this change in U.S. homicide trends. Therefore, a discussion of alternative possible explanations is required.

The most likely plausible alternative hypotheses are those based on historical change (Shadish et al., 2002, p. 179). The following discussion draws on the corresponding sections in Dillbeck and Cavanaugh (2016) and Cavanaugh and Dillbeck (2017a).

6.1.1 Economic Changes

Within the time frame studied, a strong candidate for an alternative cause of change in homicide rates is the economic disruption of 2008 and consequent recession, the most severe at that time since the Great Depression. Richard Rosenfeld, past president of the American Society of Criminology, commented that the 2008-2009 recession was the first time that property crime and violent crime and rates did not rise during a major economic downturn since World War II (Eng, 2012).

However, despite the fact that homicide is the most accurately measured violent crime, homicide and economic change as measured by unemployment do not have a clear overall relationship: research has generally yielded weak or conflicting results (Rosenfeld, 2014; Rosenfeld & Messner, 2013). A clearer relationship has been reported between unemployment and property crime (Altindag, 2012; Andresen, 2012; Cantor & Land, 1985; Phillips & Land, 2012). Similarly, Rosenfeld (2009) notes that the research literature indicates a robust relationship between property crime and changes in other measures of economic conditions such as wages, GDP, economic growth, and collective perceptions of economic conditions (consumer sentiment), but that these indicators have little or no association with trends in violent crime other than robbery (e.g., Arvanites & Defina, 2006).

Efforts to explain the anomalous decline of both property and violent crime rates during the 2008-2009 recession have focused primarily on the possible role of inflation (e.g., Rosenfeld, 2018). In a series of papers, Rosenfeld and co-

investigators have examined the hypothesis that the reduction in homicide and property crime rates during the Great Recession was due principally to the sharp decline of inflation, which fell in 2009 to the lowest level in 50 years.

The effect of inflation on homicide is said to be mediated by effects of inflation on property crime: higher inflation is hypothesized to lead to increased participation in the market for cheaper stolen goods, exposing participants to increased risk of violence (e.g., Rosenfeld & Messner, 2013). Recent studies (e.g., Nunley, Stern, Seals, & Zietz, 2016; Rosenfeld, Vogel, & McCuddy, 2019) report a positive association between U.S. inflation and acquisitive crime (robbery, burglary, larceny, and motor vehicle theft). Tang and Lean (2007) found a long-run (cointegrating) relationship between both U.S. inflation and unemployment and the U.S. total crime rate. In support of the theoretical plausibility of a direct, as well as indirect, effect of inflation on crime, Rosenfeld (2014) cites prior research connecting upswings in inflation to increased social stress resulting from economic hardship and deprivation.

Extending research on the relation between inflation and acquisitive crime, Rosenfeld and Vogel (2021) found that city homicide rates were positively associated with consumer inflation rates in a longitudinal sample of 17 U.S. cities 1960 to 2013. A significant association between inflation and homicide was evident whether or not acquisitive crime was included as a covariate. The study also controlled for the previous year's homicide rate, median income, socioeconomic disadvantage, police per capita, immigration, and the age composition of the city population; none of the latter covariates except the prior year's inflation rate were statistically significant despite ample statistical power and lack of substantial multicollinearity. This study also found a significant indirect effect, as well as direct effect, of inflation on homicide—the association between homicide rates and inflation was partially mediated by the rate of acquisitive crime.

A significant positive association of inflation and homicide has also been reported in cross-national research (Rosenfeld, 2014; Santos, Testa, & Weiss, 2021).

Whatever the merits of this research on the historical relationship between U.S. consumer inflation and homicide rates over multiple decades, the decline of consumer inflation during the 2008-2009 recession seems unlikely to provide a satisfactory alternative explanation for the findings reported in the current study. This alternative explanation is implausible because the sharp decline in U.S. consumer inflation during the recession occurred from mid-2008 to its lowest monthly value in October 2009, an decrease beginning well *after* the reduction in homicide trend that began in January 2007. The annual rate of U.S. consumer inflation was 2.85% in 2007, rose to 3.84% in 2008, and then fell to a 50-year low of −0.36% in 2009. Inflation then rebounded to 1.64% (2010) and 3.16% (2011) (World Bank, 2022), while the declining trend of homicide rates continued in 2010-2011.

To quantitatively assess the plausibility of this alternative explanation for the results reported in Table 1, we added monthly rates of inflation in the CPI-U Consumer Price Index for all Urban Consumers (not seasonally adjusted) to the regression model in Equation 1 (U.S. Bureau of Labor Statistics, 2022). Detailed regression results are presented in Tables 9 and 10 of the online supplemental files (https://osf.io/2yagh/). Inflation was calculated as the monthly change in the natural logarithm of CPI-U multiplied by 1200 to express it as an annualized percentage rate. Monthly inflation for the current month plus lagged inflation values for the four previous months were included in the regression model to assess possible lagged effects. After adding the inflation variables, continued strong support was evident for Hypotheses 1 and 2 (both $p < .0001$) with moderate to large effect sizes. The inflation variables were all nonsignificant except inflation at lag 2, which had the wrong sign (negative).

6.1.2 Changes in Incarceration

The results for homicide trends in the current study also do not appear to be plausibly explained by changes in the prison population. The incarceration rate (the total number incarcerated in all public and private U.S. prisons or jails per 100 000 population) rose steadily from 2000 to 2006, stabilized at 1000 per 100 000 population from 2007-2008, then declined steadily 2009-2012 (Glaze & Herberman, 2013). In view of the negative correlation between incarceration rates and crime (Marvell & Moody, 1994), one would expect more violent crime rather than less. However, one could plausibly assert that those convicted of homicide were less likely to be among those released than those convicted of lesser crimes. If so, then changes in the national homicide rate would display a weaker association with fluctuations in the prison population.

6.1.3 Policing

According to data from the FBI Uniform Crime Reports, the number of fulltime sworn police officers through 2012 "has remained relatively consistent since 2000 at about 2.5 officers per 100 000 U.S. residents" (Banks, Hendrix, Hickman, & Kyckelhahn, 2016). Yet improvement in police strategy or technology in some U.S. localities conceivably could have contributed to reduced homicide rates during the experimental period. For example, Richard Rosenfeld

credited improved policing in some areas (e.g., New York and Los Angeles) for reducing crime rates during the period of this study, but remarked that policing in most places was much the same as it was ten years previously (Eng, 2012). A large-scale, simultaneous implementation of effective new strategies or technologies would have been required to cause the observed reduction in national homicide trend during 2007-2011. This seems unlikely and would not predict the increase in homicide trend during the post-experimental period. Moreover, improved surveillance technology would more likely target property crimes than homicide; alcohol (and illicit drug) use would likely make homicide more intractable to effective reduction through surveillance (Roizen, 2002).

6.1.4 Demographic Changes

A key demographic factor correlated with U.S. violent crime rates is the percentage of youth in the population. For example, youth (age 18-25) is associated with greater violent crime (Nivette, 2011). Such demographic factors generally change only slowly, and thus are unlikely to contribute to abrupt changes in homicide trends. Moreover, during the period of this study the percentage of young people was gradually increasing (Howden & Meyer, 2011). Data from the U.S. Census Bureau's American Community Survey indicates that the percentage of youth aged 19-25 rose steadily each year 2008-2014 before declining in 2015-2016 (Kaiser Family Foundation, 2020). This and other possible demographic factors that may be associated with increased crime would have to have changed suddenly in January 2007 in a way to predict reduced violence during 2007-2011 and then change again in the opposite direction to predict an increase in homicide trend beginning in 2012.

6.1.5 Effect of Temperature Changes

Finally, we consider the possible impact of temperature on homicide trends. The homicide rate shows strong seasonal cycles with warmer summer months being the highest (Figure 1b). The seasonal component of the model statistically controls for this variation, producing seasonally adjusted regression coefficients. Recent cross-national research reports a positive association between annual temperature and interpersonal violence globally; an estimated 4% increase in interpersonal violence was associated with each SD increase in temperature (Hsiang, Burke, & Miguel, 2013). During the experimental period, NOAA data on average monthly temperatures for the contiguous U.S. states (NOAA, 2020) show a small decline of 0.59^{o}F (3.8% of baseline SD) relative to the five baseline years. In the post-experimental period average monthly temperatures increased by approximately 1^{o}F (6.7% of baseline SD) relative to baseline.

To control for the effect of average temperature on the homicide rate, we added the (centered) average monthly temperature (*ctemp*) to the regression model in Equation 1. After controlling for temperature, strong empirical support for Hypotheses 1 and 2 continues to be found (both $p < .0001$), with large to medium effect sizes. Full regression results for the expanded model are reported in Tables 11 and 12 in the online supplemental files (https://osf.io/2yagh/).

6.1.6 Alternative Explanations: Summary

None of the five factors discussed in this section appear to provide a viable alternative explanation for the observed overall pattern of a significant and substantively important decline in homicide trend during 2007-2011 (Hypothesis 1) followed by a subsequent increase in trend during the post-experimental period 2012-2016 (Hypothesis 2). Some of these factors would predict a rising rather than falling homicide trend during the experimental period. The findings reported in the current study also cannot plausibly be explained by pre-existing trends, seasonal influences, reasonable changes in the specified starting or ending dates of the experimental period, data outliers, or violation of other key statistical assumptions, including spurious regression effects due to nonstationarity.

6.2 Understanding Field Effects of Consciousness

6.2.1 The Search for Explanations from Physics

The results from this prospective, 15-year national social experiment provide empirical support for the hypothesis that "field effects of consciousness" created by group practice of the Transcendental Meditation and TM-Sidhi program by a theoretically-predicted number of participants (approximately the √1% of the U.S. population) contributed to a reduction in social stress in national consciousness as indicated by improved trends in monthly homicide rates during the study's experimental period 2007-2011 ($p < .0001$). This was followed by a predicted subsequent increase in homicide trends 2012-2016 ($p < .0001$) when the group fell below the required size.

The question naturally arises: Is there a theoretical explanation for such field effects from the point of view of contemporary physical science? What is the relationship, if any, of such field effects of consciousness to the field effects studied extensively by physics? Of the four fundamental force fields, the range of the weak and strong interactions are too small, operating within the atom. The gravitational force is too weak, operating at large distances and on large mass-energies. The electromagnetic (EM) force would appear to offer some promise, given that the brain

appears to be sensitive to changes in EM fields (Adey & Bawin, 1977; Lin, 1989); yet electromagnetic fields appear too weak to account for this effect (Hagelin, 1987).

Quantum physicist John Hagelin (1987) proposes that the postulated field effects of consciousness imply some sort of contact with more unified levels of natural law, on the basis of which nonlocal effects are predicted to occur. This is similar to Maharishi Mahesh Yogi's (1986a) explanation that the nonlocal effects of the experience of the field of pure consciousness during the TM and TM-Sidhi program are produced from the level of the unified field:

> The effect produced [on society] is from the level of the unified field. Because the unified field is the unmanifest basis of the whole creation, the influence spreads throughout the world. It's just like the effect when you water the root and the nourishment reaches every leaf, branch, flower, and fruit. (pp. 163-164)

Hagelin (1987) points out that a more complete understanding of field effects of consciousness requires understanding how pure consciousness interacts with unified levels of nature. After reviewing the relevant evidence, Hagelin (1987, p. 69) concludes, "Further research is needed to establish the underlying physiological mechanisms that uphold the experience of pure consciousness, and to consider what type of interface with the dynamics of fundamental scales could be supported by these mechanisms." Hagelin and a group of scholars in physics and neuroscience are currently engaged in an active investigation of possible mechanisms from physics and physiology for the postulated field effects of consciousness.

6.2.2 EEG Research

Studies of physiological factors possibly involved in such a mechanism include an EEG experiment that found significantly increased EEG coherence between pairs of different subjects at MIU who were practicing TM at precisely the time when 2500 individuals were engaged in the group practice of the TM-Sidhi program over 1000 miles away (Orme-Johnson, Dillbeck, Wallace, & Landrith, 1982). EEG coherence was measured between three subjects located in three different rooms at the time of the TM-Sidhi sessions on six experimental days during the experiment and on six control days after the end of the experiment. Study participants were blind to the purpose of the study. Analysis of variance found that mean increases in intersubject EEG coherence during the time of the distant TM-Sidhi group sessions were significantly greater during the six experimental days relative to the six control days ($p < .02$, multivariate test across all frequencies). The largest change was observed in the alpha frequency.

6.2.3 Possible Neuroendocrine Mediating Factors

A second study used Granger causality analysis (Enders, 2015) to investigate a psychoneuroendocrine mechanism that may possibly mediate field effects of consciousness (Walton, Cavanaugh, & Pugh, 2005). TS regression modeling of daily data ($N = 73$) found strong support for two theoretical predictions: (1) changes in the size of the TM-Sidhi group at MIU would temporally lead significant reductions in the overnight excretion rate of the stress hormone cortisol ($p = .004$, $f = -.369$, a medium effect) and (2) these changes in group size would lead increases in the ratio of excretion rates of serotonin metabolite 5-HIAA to cortisol in non-meditators working in a 20-mile radius of the group ($p < .0001$, $f = .549$, a large effect). Both cortisol and 5-HIAA excretion changed in the predicted (opposite) directions and displayed a significant dose-response relationship. The effects on cortisol and 5-HIAA excretion were consistent with effects found during individual practice of TM (Klimes-Dougan et at., 2020; MacLean et al., 1997).

The study controlled for trends, lagged values of dependent and explanatory variables, seasonal or other cyclical behavior, temperature, precipitation, weekend effects, and diet. Similarly, the results could not plausibly be explained by behavioral interaction, possible reverse causation, or spurious regression effects due to nonstationarity. The authors concluded that these results lend support to the hypothesis of an influence of field effects of consciousness on biochemical indicators of stress in individuals outside the TM-Sidhi group.

6.3 Scientific Anomalies and Scientific Progress

The theory and empirical findings presented in this study are anomalous from the viewpoint of prevailing theoretical perspectives in the social sciences. The search for a physical mechanism to help explain these proposed field effects of consciousness is still in process. Although Maharishi provides a theoretical framework for understanding the relationship between consciousness and social change from the point of view of the Vedic science of consciousness (Maharishi Mahesh Yogi, 1977, 1978, 1986a; Nader, 2015, 2021), the lack of a corresponding, known physical mechanism from the point of view of modern science for the field effects of consciousness discussed in this paper may be seen as a limitation of the current study.

But the absence of a known mechanism to explain new, or anomalous, discoveries or theories in science is not uncommon; nor is it necessarily an indicator that novel theories or findings are unworthy of serious consideration.

Numerous examples could be cited from all fields of science. One salient example is Isaac Newton's 1687 theory of gravity. Regarding the mechanism underlying the phenomenon of action at a distance predicted by his universal law of gravitation, Newton declared: "I have not as yet been able to deduce from phenomena the reason for these properties of gravity, and I do not feign hypotheses" (Stanford Encyclopedia of Philosophy, 2008).

Over 200 years later in his 1915 General Theory of Relativity, Einstein proposed the current dominant explanation of a physical mechanism for gravity—an effect produced by the warping, or curving, of space-time geometry by matter or energy. Although Einstein's theory of gravity has overwhelming support among physicists and many of its predictions have been repeatedly verified with great precision, anomalies exist, and new theories continue to be advanced that question the mechanism of Einstein's theory. For example, physicist Miles Mathis (2004) contends that more than 200 years after Newton, the mechanism of gravity remains mysterious: "Newton could not say how a massive object acted upon matter at a distance. Einstein cannot explain how a massive object curves space at a distance."

The search for explanations to explain anomalous discoveries or theories has been identified as an important stimulus to scientific progress (e.g., Kuhn, 2012). For example, as quoted by Sturrock (2007), Niels Bohr once remarked that "progress in science is impossible without paradox," a view echoed by quantum physicist Richard Feynman who said "The thing that doesn't fit is the most interesting" (p. 241).

7. Conclusion

Irrespective of theoretical considerations, the present study is consistent with prior research in reporting evidence of reduced U.S. homicide trends associated with the establishment of a group of individuals practicing the TM and TM-Sidhi program comprising approximately the √1% of the U.S. population. The current study extends the findings of previous research on this social experiment by (1) replicating a significant reduction in homicide trend during the experimental period using an expanded data sample with longer experimental and baseline periods and (2) confirming the prediction of a significant increase in the homicide trend during a newly added post-experimental period when the TM-Sidhi group substantially decreased in size.

The statistically and substantively significant reduction in homicide-rate trend during the experimental period, as predicted, was followed by a significant predicted increase in trend during the post-experimental period. The results of this "baseline reversal" quasi-experimental design are consistent with a posited causal influence. These theoretically predicted changes in trend in the opposite direction at the theoretically predicted times are consistent with—but, of course do not necessarily imply—a causal interpretation of these results. Also, these changes in homicide trends do not appear to be plausibly explained by other variables known to influence homicide.

Further support for a possible causal interpretation of the current empirical results is offered by four additional characteristics of the peer-reviewed empirical literature on field effects of consciousness described in Section 3 above: (1) the finding of a "dose effect" in which larger groups are associated with empirical evidence of larger social effects; (2) replication of empirical support for the hypothesis of field effects of consciousness as reported in 23 other peer-reviewed articles on such field effects in independent, scholarly journals; (3) evidence of temporal precedence as provided, for example, by cross-lagged panel analysis (or cross-correlation analysis in transfer function studies) that reveal a unidirectional lead-lag relationship in which changes in the size of the TM-Sidhi group (or percentage of TM meditators in a city) precede changes in crime rates or other outcomes; and (4) further evidence of temporal precedence provided by studies for which outcomes of prospective studies were lodged in advance with formal independent review boards and/or the press.

In the light of empirical findings discussed in previous studies of field effects of consciousness, national and provincial governments and nongovernmental organizations, especially in Latin America and Asia, have begun to quietly introduce the practice of these technologies of consciousness in education, the military, police forces, offender rehabilitation, and other areas. Empirical evaluation of the impact of these programs on measures of societal wellbeing in those countries offers many opportunities for further research.

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Appendix A

Studies of Effects on Warfare, Terrorism, and International Conflict

A.1 Studies of the √1% *Hypothesis — the Middle East*

In a prospective 1983 study in Israel at both city and national levels, a temporary group of TM-Sidhi program participants gathered in Jerusalem for two months. Before the project began, major hypotheses and the research protocol were lodged with independent review boards in the U.S. and Israel who monitored the project and reviewed the findings. The size of the group varied during this period; sometimes the group exceeded the required number for the whole of Israel, or for Jerusalem alone, or for both Israel and Lebanon together (Israeli troops were in part of Lebanon at that time) (Orme-Johnson et al., 1988). Using available daily data on multiple variables either for Israel as a whole or Jerusalem alone, impact-assessment analysis found significant improvements in QOL at city and national levels as indicated by equally weighted indices of QOL (for Jerusalem, $t(55) = 2.85$, $p < 0.01$, $f = 0.384$; for Israel, $t(54) = 4.00$, $p = 0.0001$, $f = 0.544$).

Based on data from content analysis of daily news reports, Orme-Johnson et al. (1988) also reported improvements in measures of war intensity for the Lebanese conflict ($t(55) = –2.71$, $p < 0.005$, $f = –0.365$) and war deaths ($t(55) = –2.12$, $p < 0.02$, $f = –0.286$). TF analysis showed that the size of the TM-Sidhi group temporally led the dependent variables, and not vice-versa. Responding to critiques concerning possible confounding variables (Fales & Markovsky, 1997; Schrodt, 1990), the authors' re-analyses of the data supported their initial findings (Orme-Johnson, Alexander, & Davies, 1990; Orme-Johnson & Oates, 2009).

Davies and Alexander (2005) further examined the Lebanon conflict, analyzing all seven periods during 1983-1985 when temporary TM-Sidhi groups were either in Lebanon, nearby, or further away but were large enough, according to the √1% principle, to produce a predicted effect on the conflict there. Additional analyses were based on content-analyzed daily news reports from nine international and regional sources, where the data coding was performed by an independent Lebanese rater who was blind to the hypotheses of the study. As compared to other days, during the seven days of the TM-Sidhi assemblies, Box-Tiao impact analysis found increased cooperation by factions ($t(810) = 4.96$, $p < 0.0001$, $f = 0.174$), reduced intensity of the conflict ($t(810) = –5.81$, $p < 0.0001$, $f = –0.204$), and reduced conflict fatalities ($t(814) = –6.45$, $p < 0.0001$, $f = –0.227$). The statistical analysis controlled for temperature, seasonal variation, pre-existing trends, weekends, and holidays.

A.2 Studies of the √1% Hypothesis — International Conflict and Terrorism

Using content-analyzed news reports and terrorism data from the Rand Corporation, impact-assessment analysis found a significant world-wide reduction in international conflict during three occasions of several periods of 8 to 11 days in 1983-1985 when the size of a group of TM-Sidhi participants exceeded or nearly reached the required size of √1% of the world's population based on the global population at that time (Orme-Johnson, Dillbeck, & Alexander, 2003). The analyses found a significant reduction in international conflict during each of these three occasions, with an average decline of 32% ($t(58) = -2.78$, $p < 0.005$ one-tailed, $f = -0.365$; $t(86) = -2.50$, $p < 0.01$, $f = -0.270$; $t(61) = -2.07$, $p < 0.025$ one-tailed, $f = -0.265$). Because terrorism events occurred sporadically, the terrorism data for 1983-1985 were aggregated into 219 five-day periods. Impact-assessment analysis found a 72% drop in fatalities and injuries due to terrorism ($t(209) = -1.272$, $p < 0.025$ one tailed, $f = -.088$)**.**

Appendix B

Effect Size for Regression Coefficients

The effect sizes were calculated from estimated regression coefficients reported in the original papers. The effect size (ES) measure f is the square root of Cohen's f^2 for multiple regression coefficients (Cohen, 1988), where 0.59, 0.39, and 0.14 are considered large, medium, and small effects, respectively. The latter benchmarks are the square root of those given by Cohen (1988, p. 413) for f^2 (0.35, 0.15, and 0.02, respectively). Grissom and Kim (2012, p. 323) point out that the sample value of f^2 can be written as $f^2 = F(df_n , df_d) \times (df_n / df_d)$ where df_n and df_d are the numerator and denominator degrees of freedom for the F statistic of the coefficients, respectively. For a single regression coefficient, the F statistic is $F(1, df_d)$ and its square root is the squared t-ratio $[t/(df_d)]^2$. Thus in this case may be written as $f = t/(\sqrt{df_d})$ which is the t-ratio for the regression coefficient divided by the square root of the degrees of freedom for the regression residuals. Darlington and Hayes (2017, pp. 226-228) provide an alternative derivation of this result and argue that the unsquared version of f better reflects the relative magnitude of different effects. The reported ES is approximate for models estimated with nonlinear least squares (such as ARIMA and TF models) rather than ordinary least squares (OLS).

Appendix C

Data Definitions and Sources

Monthly homicide totals for January 2002 through December 2016 were obtained from the WONDER online database of the National Center for Health Statistics of the U.S. Centers for Disease Control (CDC) (U.S. Department of Health and Human Services, 2018). Data are from the Multiple Cause of Death Files, 1999-2016.

Homicide totals were then converted to monthly rates per 100 million people using not-seasonally adjusted monthly U.S. population estimates (data series POPTHM) from the U.S. Bureau of Economic Analysis (BEA) obtained from the FRED database at the Federal Reserve Bank of St. Louis (U.S. Bureau Economic Analysis, 2017). The monthly rate per 100 million people was then divided by the number of days in each month to obtain the mean daily homicide rate per month (*homr*). This adjustment was intended to remove any serial correlation in the data simply due to the differing number of days in each month.

This method of calculation of the homicide rate replicates that used in Dillbeck and Cavanaugh (2016), except that monthly population estimates from the BEA were used in the current study instead of linearly interpolated 2010 Census population figures. The daily number of group participants in the afternoon meditation session was provided by the Department of Development of Consciousness at MIU and converted into monthly averages. The source of monthly data for the U.S. Consumer Price Index for All Urban Consumers, not seasonally adjusted (series CPIAUCNS) is the U.S. Bureau of Labor Statistics (2022) and the annual rate of CPI inflation (series FPCPITOTLZGUSA) is from the World Bank (2022). U.S. incarceration data and number of sworn police per 1000 population were obtained from the Bureau of Justice Statistics, U.S. Department of Justice (refer to citations in the text). Monthly mean U.S. temperature data was obtained from the online database of the National Oceanographic and Atmospheric Administration (NOAA) (2020).

Appendix D

Derivation of Treatment Effect

The mathematically expected value of the homicide rate in December 2011 is $E(y_t \mid \boldsymbol{z_t}) = \beta_0 + \beta_1 60 + (\beta_1 + \beta_2)60 + S_{12}$, where y_t is the homicide rate and $\boldsymbol{z}_t$is a vector of explanatory variables and S_{12} is the seasonal coefficient for December; the corresponding expected counterfactual value is $E(y_t \mid \boldsymbol{z}_t) = \beta_0 + \beta_1 120 + S_{12}$. Subtracting the observed expected value from the counterfactual value yields the expected treatment effect: $E(\mathrm{TE} \mid \boldsymbol{z}_t) = 60\beta_2$.

Supplemental Files: To access online supplemental files, go to https://osf.io/2yagh/ and create a free OSF account. Sign in. Search for "Evaluating a Field Theory of Consciousness and Social Change." Then click on the paper title to bring up the page listing supplemental files.