HHS Public Access
Author manuscript
J Pers Soc Psychol. Author manuscript; available in PMC 2016 February 01.

Published in final edited form as:
J Pers Soc Psychol. 2015 February ; 108(2): 336–355. doi:10.1037/a0038322.

Neural and Behavioral Evidence for the Role of Mental Simulation in Meaning in Life

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Abstract

Mental simulation, the process of self-projection into alternate temporal, spatial, social, or hypothetical realities is a distinctively human capacity. Numerous lines of research also suggest that the tendency for mental simulation is associated with enhanced meaning. The present research tests this association specifically examining the relationship between two forms of simulation (temporal and spatial) and meaning in life. Study 1 uses neuroimaging to demonstrate that enhanced connectivity in the medial temporal lobe network, a subnetwork of the brain's default network implicated in prospection and retrospection, correlates with self-reported meaning in life. Study 2 demonstrates that experimentally inducing people to think about the past or future versus the present enhances self-reported meaning in life, through the generation of more meaningful events. Study 3 demonstrates that experimentally inducing people to think specifically versus generally about the past or future enhances self-reported meaning in life. Study 4 turns to spatial simulation to demonstrate that experimentally inducing people to think specifically about an alternate spatial location (from the present) increases meaning derived from this simulation compared to thinking generally about another location or specifically about one's present location. Study 5 demonstrates that experimentally inducing people to think about an alternate spatial location versus one's present location enhances meaning in life, through meaning derived from this simulation. Study 6 demonstrates that simply asking people to imagine completing a measure of meaning in life in an alternate location compared to asking them to do so in their present location enhances reports of meaning. This research sheds light on an important determinant of meaning in life and suggests that undirected mental simulation benefits psychological well-being.

Keywords

self-projection; mental simulation; meaning in life; mental time travel; default network

Possessing meaning in life—the sense that one's life is coherent, is significant, and has purpose (Heintzelman & King, 2014a; 2014b)—is essential to human functioning. Meaning in life has widespread benefits for well-being, contributing to reduced suicidal ideation

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(Harlow, Newcomb, & Bentler, 1986), lower depression and anxiety (De Bats, Van Der Lubbe, & Wezeman, 1993), and greater happiness (Chamberlain & Zika, 1988; Janoff-Bulman, 1992). Possessing meaning even benefits physical health (Taylor, Kemeny, Reed, Bower, & Gruenewald, 2000) and protects against mortality (Krause, 2009). Although psychological contributors to meaning in life are well established, they are also highly variable, ranging from proximal factors such as positive mood (King, Hicks, Krull, Del Gaiso, 2006) to broader constructs such as social connection or religion (Cacioppo, Hawkley, Rickett, & Masi, 2005).

Many disparate factors that contribute to perceptions of meaning may actually stem from the same psychological process: simulation. Simulation—also known as self-projection—involves mentally transcending the "here-and-now" to occupy psychologically a different time (past or future), a different place, a different person's subjective experience, or a hypothetical reality. In other words, simulation involves conjuring up the experience of something other than that which one is currently experiencing. The richest form of this capacity for simulation appears to be distinctively human (Gilbert, 2009), with some theorists speculating simulation is *the* capacity that allows humans to participate in complex culture through navigating the past, future, and the social world (Baumeister & Masicampo, 2010).

Simulation and meaning in life

Different forms of simulation involve a similar psychological process (Trope & Liberman, 2003; Trope & Liberman, 2010) and moreover, multiple forms of simulation appear related to meaning in life. Broadly speaking, people process events that are psychologically distant (versus psychologically near) in broader, more abstract terms rather than in concrete details (Liberman & Trope, 2008; Trope & Liberman, 2003; Trope & Liberman, 2010), and such abstract construals of events correspond to perceptions that the event was "meant to be" (Burrus & Roese, 2006). People also attempt to cope with threats to their sense of meaning by construing actions in more abstract, high-level terms versus concrete, low-level terms (Landau, Kosloff, & Schmeichel, 2011). In general, results that link abstract construal to meaning support the hypothesized, but as of yet unobserved link between the simulation of psychological distance and perceived meaning in life.

Research also supports the idea that specific forms of simulation are related to increased meaning in life. For example, specific forms of temporal simulation—both retrospection and prospection—appear to enhance meaning. In terms of retrospection, nostalgia, the process of sentimentally reflecting on past events, has been shown to increase perceived meaning in life (Routledge, Sedikides, Wildschut, & Juhl, 2013). For instance, the dispositional tendency to engage in nostalgia mitigates the effects of existential threats to one's sense of meaning (Juhl, Routledge, Arndt, Sedikides, & Wildschut, 2010; Routledge, Arndt, Sedikides, & Wildschut, 2008). Furthermore, experimentally inducing people to engage in nostalgic thinking increases their self-reported sense of meaning in life (Routledge, Arndt et al., 2011; Routledge, Wildschut, Sedikides, Juhl, & Arndt, 2012).

Similar to thinking positively about one's past through nostalgia, thinking positively about one's future also corresponds to meaning in life. For example, self-reported hopeful thinking, a form of positive consideration of one's future, is related to self-reported meaning in life (Feldman & Snyder, 2005). In addition, consideration of one's future legacy is linked to meaning in life (Fox, Tost, & Wade-Benzoni, 2010; Wade-Benzoni & Tost, 2009; Wade-Benzoni, Tost, Hernandez, & Larrick, 2012).

Another form of simulation unrelated to positivity that enhances meaning is counterfactual thinking, imagining hypothetical alternatives to specific past events (Galinsky, Liljenquist, Kray, & Roese, 2005; Kray, Hershfield, George, & Galinsky, 2013; Lindberg, Markman, & Choi, 2013). Specifically, imagining alternative ways that an event could have occurred (but did not) enhances the perceived meaningfulness of the event that actually occurred. Some studies have asked people to imagine counterfactual pasts in which one's country or company might not have come into existence, and found that people ascribed more meaning to and reported a greater sense of commitment toward these institutions (Ersner-Hershfield, Galinsky, Kray, & King, 2010). Similarly, asking people to reflect through counterfactual thinking on how personal relationships and key life turning points might not have emerged enhances the perceptions that those relationships and events were "meant to be" (Koo, Algoe, Wilson, & Gilbert, 2008; Kray, George et al., 2010). Even thinking about how one's birth might not have occurred can enhance meaning about one's life generally (Heintzelman, Christopher, Trent, & King, 2013). Thus, this specific form of simulation—counterfactual thinking about how an event might have occurred differently—enhances the perceived meaning of those events.

Research on nostalgic retrospection, positively-oriented prospection, and counterfactual thinking provide clear suggestive evidence of a relationship between mental simulation more broadly and meaning in life. However, other research on processes related to simulation also provides more indirect evidence for this link.

A process related to simulation that enhances the meaning of specific events is self-distancing, mentally stepping outside of oneself to adopt a third-person perspective on past personal events (Kross & Ayduk, 2011). Although only tangentially related to simulation, self-distancing involves transcending one's current experience into that of a distant observer, as though the "self becomes other" (Kross, 2009, p. 35). Studies that have asked participants to adopt a self-distanced perspective versus a self-immersive perspective on negative events demonstrate that this third-person perspective allows people to derive meaning from specifically negative events (Ayduk & Kross, 2008, 2009; Kross & Ayduk, 2008, 2009; Kross, Ayduk, & Mischel, 2005). In these studies, meaning derives from reduced emotional and physiological distress in response to negative events. In addition, individuals who are naturally inclined to engage in self-distancing show greater capability to make meaning from ostensibly distressing events such as hostility within a personal relationship (Ayduk & Kross, 2010; Grossman & Kross, 2010). Thus, this process appears to enhance meaning associated with specifically negative events.

Just as imagining the self as "other" through self-distancing can create meaning, a more direct form of other-oriented simulation, using one's theory of mind to adopt others' perspectives, can also enhance meaning. At a basic level, considering the mental states of others' actions corresponds to construing those actions in higher-level, more meaningful, goal-oriented terms (rather than concrete, mechanistic terms) (Kozak, Marsh, & Wegner, 2006). In an earlier demonstration of how consideration of mental states enhances meaning, Heider and Simmel (1944) asked participants to describe an animation of shapes moving around a screen in a manner that resembled social interaction. In describing how participants derived meaning from this short film, Heider (1958/1964, pp. 31–32) wrote, "As long as the pattern of events shown in the film is perceived in terms of movements as such, it presents a chaos of juxtaposed items. When, however, the geometrical figures… are perceived in terms of motives and sentiments, a unified structure appears." In other words, simulating the mental states underlying these shapes' actions makes their actions seem meaningful. Similarly, inducing people to describe the actions of nonhuman entities (e.g., an alarm clock, a dog, an animated set of shapes, a robot) by considering their mental states (versus their mechanistic actions) increases people's ability to make sense of these entities (Waytz, et al., 2010). In sum, these studies suggest a process related to simulation, stepping outside one's own mind to consider the minds of others (even nonhuman others), enhances the construal of their actions as meaningful.

Beyond day-to-day perspective-taking with others, attempting to simulate the mind—the intentions or plans—of some external source such as a higher power can give one a sense of meaning. Bering (2002, p.3) refers to this process as the "existential theory of mind," where by people consider their life events to be meaningful through inferring that some metaphysical agent (e.g., God) has intended these events to be. This consideration of the beliefs and intentions of an ostensible higher power forms the basis of much religious thinking (Barrett, 2000; Bloom, 2007; Boyer, 1994; Epley, Waytz,& Cacioppo, 2007; Guthrie, 1995; Norenzayan, Gervais, & Trzesniewski, 2012), which itself provides a source of meaning for people. Religion provides meaning in particular for negative events (e.g., experiencing cancer), by enabling people to see such events as willed, or intended by a higher power (Lynn Gall & Cornblat, 2002; Howsepian & Merluzzi, 2009; Pargament, 1997; see Park, 2013 for review). Religion also provides meaning for events that are difficult to comprehend, and are therefore attributed to the willful mind of a divine creator. In this regard, people tend to maintain at least implicit beliefs that the complex workings of nature (the development of a mountain or a rock) result from the intelligent plans of a supernatural agent (e.g., Kelemen, 2004; Kelemen & Rossett, 2009; Kelemen, Rottman, & Seston, 2013). What is more, when people lack well-developed causal reasoning capacities, they become particularly prone to these teleological explanations (DiYanni & Kelemen, 2005; Lombrozo, Kelemen, & Zaitchik, 2005), suggesting that inferring the intentions of a supernatural designer provides a sense of understanding of nature. Taken as a whole, religion seems to provide a pervasive source of meaning, in part because it often involves a particular form of simulation—using one's theory of mind to consider the mental states of a metaphysical agent—to make sense of one's life and the world more generally.

The research reviewed above provides initial evidence that across numerous domains, simulation—mentally projecting oneself beyond the here and now—appears to enhance perceptions of meaning in specific events and in life more generally. Nostalgically reflecting on the past or hopefully contemplating the future enhances reports of meaning. Specifically simulating counterfactual alternatives to events that have happened increases the perceived meaning of those events. Adopting a third-person perspective on negative events as though one were another person altogether enables to derive meaning from those events. Simulating the mental states of others enhances meaning through enabling people to make sense of others' actions. Finally, simulating the mental states of a higher, metaphysical agent through explicit or implicit religious thinking can also enable people to derive meaning from specific events.

Despite these consistent links across independent domains of research, the direct relationship between simulation and meaning in life has not yet been explicitly tested. What is more, the research reviewed above involves either a targeted form of simulation (e.g., specifically simulating positive experience in the past through nostalgia, or specifically simulating a negative alternative experience through counterfactual thinking), a targeted event for which one perceives meaning (e.g., being diagnosed with cancer), or both. The present research goes beyond these existing findings to assess whether non-targeted simulation in *general* (rather than specifically positive or negative simulation) corresponds to and predicts meaning in life in *general*. In addition, the present research advances research on this topic in five additional ways: (1) to establish that temporal simulation generally (rather than *either* retrospection or prospection uniquely) enhances meaning in life, (2) to establish that detailed versus general simulation enhances meaning in life, (3) to examine the underlying process driving these effects, (4) to explore whether spatial simulation enhances meaning in life to a similar degree as temporal simulation, and, (5) to provide evidence that functioning of the neural networks involved in simulation influences general perceptions of meaning in life

Regarding the latter point, relatively little work in neuroscience has investigated meaning in life, with a handful of studies examining neural responses to meaning violations (Inzlicht, McGregor, Hirsh, & Nash, 2009; Inzlicht & Tullett, 2010; Quirin, Loktyushin, Arndt, Küstermann, Lo, Kuhl, & Eggert, 2012; Silveira et al., 2013; Tullett, Prentice, Nash, Teper, Inzlicht, McGregor, 2013) and one study demonstrating a correlation between asymmetric left versus right superior frontal activation and self-reported eudaimonic well-being (Urry, Nitschke et al., 2004). Therefore, the present research attempts to fill this gap in the literature by focusing on a well-established neural network for simulation.

Emerging evidence in neuroscience has suggested that a unified neural network, termed the "default network" (Raichle, Macleod, et al., 2001), is implicated in all different forms of simulation. The default network comprises a set of brain regions that includes the medial prefrontal cortex (MPFC), medial parietal cortex, lateral parietal cortex, and regions within medial and lateral temporal cortex. Meta-analyses over studies on multiple forms of simulative processes all converge on this same network of regions (Buckner & Carroll, 2007; Schacter & Addis, 2007; Spreng, Mar, & Kim, 2009) and empirical work demonstrates that different forms of simulation engage this same network as well (Tamir & Mitchell, 2011). For example, this network is engaged when people simulate the minds of other people (Amodio & Frith, 2006; Frith & Frith, 2006; Gallagher & Frith, 2003; Gallagher, Happe, Brunswick, Fletcher, Frith, & Frith, 1999; Saxe & Kanwisher, 2003) and when people imagine themselves in the past or future, regions in this network also become engaged (Addis, Wong, & Schacter, 2007; Mason, Bar, & Macrae, 2009; Schacter, Addis, & Buckner, 2007). Regions in this network are also involved when people contemplate hypothetical worlds (Hassabis & Maguire, 2009), consistent with this network's involvement in transcendence of the here and now.

Overview of Studies

The present research involves six studies that test the link between mental simulation and meaning in life, terms that we specify here. Regarding *mental simulation*, the present studies first examine temporal simulation for two reasons: (1) Research such as that reviewed above as well as survey data suggesting that meaningfulness involves integrating the past and present with the future (Baumeister, Vohs, Aaker, & Garbinsky, 2013) has closely linked temporal simulation to meaning in life,(2) Our data-driven approach (described below) builds on the results of Study 1, which suggest that this form of simulation in particular contributes to a sense of meaning. We then build on these findings in Studies 4–6 by examining the link between spatial simulation and meaning in life in order to test the generalizability of these findings, as well as a mechanism for this effect.

Regarding *meaning in life*, although studies reviewed above differ subtly in their conceptualization and operationalization of this construct, they converge in important ways, all involving one of three components of meaning noted by Heintzelman and King (2014a; 2014b): coherence, significance, and purpose. Thus, the present research defines meaning in life as the sense that one's life is coherent, is significant, and has purpose, consistent with Steger, Frazier, Oishi, and Kaler's (2006, p. 81) commonly used definition, "The sense made of, and significance felt regarding, the nature of one's being and existence.".

In Study 1, we hypothesize that because the default network supports the capacity for simulation, and that simulation enhances meaning in life, greater connectivity, or temporally correlated patterns of activation, in this network would be related to increased perceptions of meaning in life. Recent work on the default network has separated this network into three functionally and anatomically dissociable subsystems. These subsystems include (i) a medial-temporal lobe (MTL) subsystem that includes the hippocampal formation, parahippocampal cortex, retrosplenial cortex, and posterior intraparietal lobe; (ii) a dorsomedial PFC (dMPFC) subsystem that includes the dMPFC, lateral temporal cortex, and temporal-parietal junction; and (iii) a core subsystem that involves the posterior cingulate cortex (PCC) and ventromedial prefrontal cortex (vMPFC) (Andrews-Hanna, Reidler, Huang, & Buckner RL, 2010; Yeo, Krienen et al., 2011). To examine whether greater coherence in the default network would be related to enhanced meaning in life, in Study 1 we assessed the correlation between meaning in life and functional connectivity in each of these subsystems. In doing so, we took a data-driven approach to this research question, speculating that connectivity in any of these subsystems involved in various forms of simulation would be related to meaning in life, with the null hypothesis that none of these subsystems would be related to meaning in life. Through inductive reasoning (Cacioppo, Semin, & Berntson, 2004), we conducted Studies 2 and 3 based on the findings of this initial study and the respective functions of each of these networks.

Studies 2 and 3 involve a purely behavioral approach to examining the link between mental simulation and meaning in life. Study 2 induced people to engage in temporal simulation—asking them to write about the past or future—and hypothesized that this induction increases self-reported meaning in life compared to inducing people to write about the present. Study 3 hypothesized that inducing people to engage in enhanced temporal simulation versus basic temporal simulation—through asking them to write about the past/future in detailed versus general terms—enhances meaning in life. Study 4 then expands the test of simulation to include a manipulation of spatial, rather the temporal, distance, and examines the effect of simulation on event-derived meaning. Likewise, Study 5 uses an overt manipulation of spatial simulation and Study 6 uses a subtle manipulation to test the effect of spatial simulation on meaning and to provide further clarity on mechanisms driving the effect. Taken together, these studies test the overarching hypothesis that at least two forms of mental simulation—both temporal simulation via retrospection or prospection as well as spatial simulation—enhances meaning.

Study 1

In this first study, we measured functional brain connectivity in participants during neuroimaging scanning in which they rested passively for 372 seconds. Later, participants completed a battery of behavioral measures distributed online, including the meaning in life questionnaire (MLQ) (Steger et al., 2006) that includes a subscale measuring self-reported *presence* of meaning in life (presence subscale).

Method

Our study population came from a sample of individuals who underwent neuroimaging between June 2009 and December 2011 and who had usable neuroimaging data. Afterwards, we emailed all individuals for whom we had contact information with the opportunity to complete an online questionnaire using Qualtrics software, in exchange for entry into a $25 lottery. Our sample resulted in 84 individuals (43 female, 33 male, eight unreported, M_{age}=25.34, SD=9.90) who had useable neuroimaging data and completed at least one of the measures of our behavioral survey (note that degrees of freedom vary slightly in our analyses because not all participants completed or had usable data for all measures). As is the case with this study and all studies below, all measures are reported.

Behavioral Assessment—The survey consisted of demographic questions and a number of personality measures included as part of a multi-study project, yet we made a priori predictions that meaning in life would be correlated with connectivity in the default network. The following measures were presented, in a randomized order: an altruism task that required people to divide money between themselves and another person, the Satisfaction With Life Scale (Diener, Emmons, Larsen, & Griffin, 1985), Beck Depression Inventory (Beck, Steer, & Brown, 1996), the Purpose in Life Scale of Psychological Well-Being (Ryff, 1989), the Responses to Positive Affect Questionnaire (Feldman, Joorman, & Johnson, 2008), the Altman Self-Rating Mania Scale (Altman, Hedeker, Peterson, & Davis, 2007), the Interpersonal Reactivity Index (Davis, 1980), the Autism Quotient (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001), the Personal Altruism Level Scale

(Tankersley, Stowe, & Huettel, 2007), the Author Recognition Test (Stanovich & West, 1989), and our primary measure of interest, the Meaning in Life Questionnaire (MLQ) (Steger et al., 2006). This questionnaire consists of ten statements evaluated on a 7-point scale (1=*absolutely untrue*, 7=*absolutely true*), that separates into two subscales, one assessing people's perceived presence of meaning in life (presence subscale) and one assessing people's search for meaning in life (search subscale). The presence subscale was completed by 81 individuals and served as our primary measure of presence of meaning in life. We computed scores for all measures and subscales of all measures.

Neuroimaging Assessment—The neuroimaging measure we examine in this study is intrinsic functional connectivity. Functional connectivity here refers to the degree to which multiple brain regions within a single network show temporally correlated patterns of activity (Park & Friston, 2013), and is typically examined while subject participants are passively resting, awake in an fMRI scanner. This measure is distinct from assessment of task-induced activation in unique brain regions, and effectively assesses the degree to which different regions within the same network operate in a coherent fashion.

To assess functional connectivity during rest, each participant completed one run of functional neuroimaging scanning in which they rested passively with their eyes open for 372 s. This run was always conducted as an ancillary aspect of other studies—before or after tasks ranging from economic choice, to evaluation of social stimuli, to simple cognitive processing. These resting state data were collected using a gradient-echo echo-planar pulse sequence (TR = 3000ms; TE = 30ms) on a 3T Siemens Trio. Images were acquired with 47 axial slices (0 skip) and 3mm isotropic voxels. The first four volumes of the run were discarded to allow for signal stabilization. Image preprocessing then corrected for slice-time acquisition differences (Wellcome Department of Cognitive Neurology, London, UK) and for head motion (FSL, FMRIB, Oxford, UK); volumes were then normalized to a T1 EPI template in MNI atlas space (SPM2), smoothed with a 6mm FWHM Gaussian kernal, low-pass filtered to remove frequencies above .08Hz, and filtered to remove linear trends. Nuisance variables were removed using partial regression. Nuisance variables included the six motion correction parameters, global signal, average signal within the lateral ventricles, and average signal within white matter, as well as the temporal derivatives of each nuisance variable.

Using these preprocessed data, we then assessed the degree of functional connectivity within five neural networks: three subnetworks of the default network and within two networks we picked as discriminant controls. The regions comprising each network were defined based on work by Yeo et al. (2011). This previous research used clustering analyses over functional resting state data from 1,000 subjects in order to identify 17 separable networks of the brain. Each of the 17 networks identified contain multiple non-overlapping and reliably functionally coupled regions. This method of parcellating the brain into functional networks separates the default network into three subnetworks: 1) A network that comprises retrosplenial cortex, parahippocampal cortex, and the ventral inferior parietal lobule, 2) A network that comprises dorsomedial prefrontal cortex (dMPFC), anterior inferior parietal lobe, a portion of the lateral temporal cortex, ventral prefrontal cortex, and right lateral posterior prefrontal cortex, and 3) A network that comprises medial prefrontal cortex, posterior cingulate cortex, posterior inferior parietal lobe, and a portion of the lateral temporal cortex. This segmentation of the default network is similar – though notably not identical to – previous work on the functional parcellation of the default network (Andrews-Hanna, Reidler, Sepulcre, Poulin, Buckner, 2010), and as such, we adopt the naming scheme from this previous work for the present research: 1) *medial temporal lobe (MTL) subsystem*, 2) *dorsomedial prefrontal cortex (dMPFC) subsystem*, and 3) the *core subsystem*. While our primary analysis focused on these default subnetworks, we also included two additional networks in the analysis as discriminant controls: the *dorsal attention network*, which comprises the frontal eye fields, posterior temporal cortex, ventral precentral cortex and intraparietal sulcus, and the *frontoparietal control network*, which comprises dorsolateral prefrontal cortex, inferior parietal lobe, posterior dorsomedial prefrontal cortex, lateral anterior prefrontal cortex, and a portion of the lateral temporal cortex. These networks were chosen as a control because they are known to be anticorrelated with the default network (Fox, Snyder, Vincent, Corbetta, Van Essen, & Raichle, 2005), and are contiguous with, but functionally distinct from, regions of the default network, respectively. Regions from all 17 networks, masked with a liberal cortical mask, are available through freesurfer (http://www.freesurfer.net/fswiki/CorticalParcellation_Yeo2011); all regions larger than 20 voxels were included in our functional connectivity analyses. All regions are bilateral unless otherwise noted.

Functional connectivity within each network was calculated as follows: First, we calculated the average timecourse in each region in the network. We then calculated the correlation between the average timecourse in each region in one network with the average timecourse in each other region within that network. These correlations were then transformed to z-scores. These z-scores were then averaged to produce the final measure of functional connectivity within a network.

Results

We first examined correlations between all behavioral measures and all measures of connectivity for the subsystems of the default network separately—the MTL subsystem, the core subsystem, and the dMPFC subsystem—and for discriminant validity, connectivity measures for the frontoparietal control network and the dorsal attention network. Notably, the only connectivity measure that correlated significantly with presence of meaning in life was the MTL subsystem connectivity measure, $r(79)=.25$, $p=.022$ (search for meaning in life was not correlated with any networks, all *r*s<[.09], *p*s>.45). To test the robustness of this finding we also conducted a bootstrapping analysis on the correlation between the MTL network and presence of meaning in life. This analysis also revealed a significant correlation, $r=.25$, $p<.022$ (95% CI=0.035, 0.447; 1000 resamples; *bias*=0.000, *se*=0.106). We then subjected this finding to a number of tests to demonstrate its validity. First, using Steiger's (1980) z-test, we compared this correlation with correlations between measures of connectivity in other networks and presence of meaning to show that it was significantly greater than the correlation between presence of meaning and the core subsystem, the dMPFC subsystem, or frontoparietal control network (*z*s>2.22, *p*s<.027; $z=1.59$, $p=.11$ for a comparison with the $r=-.003$ correlation between presence of meaning and dorsal attention network connectivity). Second, we controlled for connectivity in other default network subsystems. MTL subsystem connectivity continued to predict presence of meaning in life, even when including measures of connectivity in the dMPFC subsystem and the core system as regressors, β=.34, *t*(77)=2.73, *p*=.008.

Recently, it has been suggested that in-scanner head movement can influence connectivity results (Van Dijk, Sabuncu, & Buckner, 2012). To account for head movement, we calculated motion during the passive rest and assessed its relation with our variables of interest. Motion was measured as the mean amount of linear displacement within the x y and z dimensions (calculated as $\sqrt{(\Delta x^2+\Delta y^2+\Delta z^2)}$) between each time-point. Mean displacement was not uniquely correlated with the MTL subsystem, but rather correlated negatively also with the core subsystem, the dMPFC subsystem, and the frontoparietal subsystem (all *r*s≤−.23, all *p*s≤.04). Furthermore, mean displacement was not at all correlated with presence of meaning, *r*(78)=−.04, *p*=.71. Finally, we assessed the correlation between MTL connectivity and presence of meaning while controlling for mean displacement, and the correlation remains significant, *r*(75)=.25, *p*=.026. These results suggest that head movement had little effect on our primary findings.

We also examined correlations between MTL subsystem connectivity and other personality measures from the online behavioral portion of the study (see Table 1 for all correlations and MTL/presence of meaning correlations controlling for all other measures). The only other significant correlation to emerge was between MTL subsystem connectivity and the subscale assessing emotion-focused positive rumination from the Responses to Positive Affect Questionnaire, *r*(79)=.24, *p*=.029. A nearly significant correlation emerged between MTL subsystem connectivity and mania, *r*(79)=.21, *p*=.056 and a marginal correlation emerged between MTL subsystem connectivity and the social seeking behavior subscale of the Autism Quotient, *r*(76)=−.20, *p*=.079. The social seeking behavior subscale was marginally negatively related to presence of meaning in life, *r*(76)=−.19, *p*=.093 whereas both emotion-focused positive rumination (*r*(78)=.32, *p*=.004) and mania (*r*(80)=.33, *p*=.003) were significantly correlated with presence of meaning in life. We hesitate to speculate on social-seeking behavior as it is only marginally related to both MTL subsystem connectivity and presence of meaning in life. The relationship between presence of meaning in life, emotion-focused positive rumination, and mania is sensible in that emotion-focused positive rumination and mania are known to be related (Johnson, McKenzie, & McCurrich, 2008) and the experience of positive emotion is a predictor of meaning in life (Fredrickson, 2001; 2003; King et al., 2006). These constructs also converge in their positive relationship to approach motivation (Harmon-Jones, Abramson et al., 2002; McGregor, Nash, Mann, & Phills, 2010; Urry et al. 2004). Furthermore, the finding that MTL subsystem connectivity and emotion-focused positive rumination are correlated is particularly interesting in light of recent research demonstrating a relationship between rumination on *negative* emotions and overall default network connectivity (Berman, Peltier, Nee, Kross, Deldin, & Jonides, 2011). Together, these findings suggest that components of the default network contribute to rumination on one's affective state regardless of the valence of this state. In Studies 2–6, we explore the role of affect in further depth.

Overall, the finding that MTL subsystem connectivity is related only to measures with some degree of correlation with presence of meaning in life further bolsters the meaningfulness of our initial MTL subsystem/presence of meaning correlation. Interestingly, MTL subsystem connectivity did not correlate significantly with two other measures closely related to meaning in life, the Purpose in Life Scale of Psychological Well-Being, $r(78)=.17$, $p=.13$, and the Satisfaction with Life Scale, $r(79)=.17$, $p=.12$. Given that these measures assess subjective well-being more broadly (Diener et al., 1985; Springer & Hauser, 2006) rather than meaning in life specifically, one possibility is that MTL subsystem connectivity is potentially related to this specific facet of subjective well-being—meaning in life—rather than general life satisfaction. On the other hand, given the strength and direction of these correlations, it is possible that a larger sample would have revealed significant positive correlations.

To explore this pattern of results further, we conducted separate regressions predicting presence of meaning from MTL connectivity while also controlling for purpose in life and satisfaction with life. MTL connectivity remained marginally significant in both cases ($\beta=.16$, $t(77)=1.70$, $p=.093$; $\beta=.16$, $t(77)=1.69$, $p=.095$, respectively). Purpose in life and satisfaction with life were also predictors of presence of meaning ($\beta=.52$, $t(77)=5.49$, $p<.0001$; $\beta=.54$, $t(77)=5.70$, $p<.0001$, respectively). Given the strong relationship between presence of meaning, purpose in life, and satisfaction with life (see Table 2 online for correlations between all measures: http://bit.ly/Table_2), we standardized each one and averaged them to produce an omnibus measure of meaning, purpose, and happiness ($\alpha=.77$). Consistent with our primary results, MTL connectivity was significantly correlated with this omnibus measure as well, $r(80)=.24$, $p=.028$ (correlation remains significant excluding one participant who only completed the satisfaction with life scale and one participant who only completed the meaning in life questionnaire; $r(78)=.24$, $p=.033$).

Finally, we determined that age did not correlate with either MTL connectivity ($r(74)=-.04$, $p=.77$) or presence of meaning ($r(78)=.07$, $p=.52$). Given that age is known to influence various forms of mental simulation (Lang & Carstensen, 2002) as well as functional connectivity in the MTL network (Grady, McIntosh, & Craik, 2004), it was important to rule out that the relationship between MTL connectivity and meaning was not simply a result of age.

The MTL subsystem is involved in various simulation processes, but it is most strongly associated with temporal simulation, when people engage in mental time travel to experience the past or future. Research has demonstrated that when people generate episodic memories or make episodic future predictions, this network is engaged (Andrews-Hanna, 2012; Andrews-Hanna et al., 2010; Cabeza & St. Jacques, 2007; Hassabis, Kumaran, & Maguire, 2007; McDermott, Szpunar, & Christ, 2009; Schacter & Addis, 2009; Spreng et al., 2009; Svoboda, McKinnon, & Levine, 2006). Furthermore, this network appears preferentially active when people engage in detailed (versus general) simulation such as the recall of specific experiences (versus recalling the basic essence of experiences or recalling experiences that are repeated over time) (Addis, Cheng, Roberts, & Schacter, 2011; Holland, Addis, & Kensinger, 2011; Levine, Turner, Tisserand, Hevenor, Graham, & McIntosh, 2004; Nadel & Moscovitch, 1997; Viard, Desgranges, Eustache, & Piolino, 2012). The MTL subsystem may indeed be involved in a variety of psychological processes, but vivid, detailed temporal simulation appears to be a primary function of this network. Thus, the present data suggest detailed simulation, particularly temporal simulation, is related to meaning in life.

Though this conclusion is bolstered by the wealth of research (reviewed above) supporting the relationship between the MTL network and processes of prospection and retrospection, this interpretation relies on reverse inference (Poldrack, 2006), the inference of a particular psychological process from connectivity in a particular brain network. Thus, we followed Poldrack's (2008, p. 224) suggestion that "reverse inference will be most useful when it is used to drive subsequent behavioral or neuroimaging studies" to design Studies 2 and 3 to test our interpretation.

Given that the results of Study 1 show a distinctive relationship between meaning in life and the MTL subsystem, and given the MTL subsystem's role in simulation for specific experiences, we conducted Studies 2 and 3 to test the idea that detailed simulation, with a focus on temporal simulation in particular, is causally related to perceived meaning in life. In particular, Study 2 tests the hypothesis that engaging in mental time travel through simulating past or future experiences enhances meaning in life compared to reflecting on the present. Study 3 tests the hypothesis that simulating *detailed* past and future experiences enhances meaning in life compared to simulating *general* past and future experiences. Because mental time travel into the past and future tend to rely on similar mechanisms (D'Argembeau & Van der Linden, 2006) we made no predictions distinction past versus future thinking. Rather, we simply predicted that temporal simulation would differ from present thinking (Study 2) and that detailed temporal simulation would differ from general temporal simulation (Study 3). After testing the specific relation between temporal simulation and meaning in life, in Studies 4–6 we turn our attention to another type of simulation—spatial simulation—to test the generalizability of these findings.

Study 2

Study 2 randomly assigned participants either to describe two past events (past condition), describe two future events (future condition), or describe two events occurring in the present (in the past 24 hours) (present condition). Following this manipulation, all participants completed the MLQ.

Method

Our sample included three hundred fifteen people (144 female, 159 male, 12 other or unreported, M_{age}=29.51, SD=10.62) who were recruited from the Amazon Mechanical Turk marketplace (MTurk) (Buhrmester, Kwang, & Gosling, 2011) for a small monetary reward and completed the study in full using Qualtrics software.

Participants were randomly assigned to the future, past, or present condition. In the future condition, they were asked to write separately about two discrete events that will occur up to 40 years from now. In the past condition, they were asked to write separately about two discrete events that occurred up to 40 years ago. In the present condition, they were asked to write separately about two discrete events that occurred today. In all conditions, participants were instructed to write about each event in "as much detail as possible." Following this manipulation of temporal focus, all participants completed the Meaning in Life Questionnaire and completed demographic information.

Results

An omnibus comparison of presence of meaning between condition revealed a significant effect, $F(2, 312)=3.16$, $p=.044$, $\eta_p^2=.02$ (no significant omnibus comparison emerged for search for meaning, $F(2, 312)=1.88$, $p=.15$, $\eta_p^2=.01$). We then examined predicted differences between temporal simulation of the past *or* future compared to consideration of the present. This pattern was reflected in a planned orthogonal contrast demonstrating that participants in the future condition (−1) ($M=4.77$; $SD=1.33$) and past condition (−1) ($M=4.82$, $SD=1.29$) reported more presence of meaning in life than participants in the present condition (+2) ($M=4.40$, $SD=1.40$), $t(312)=2.49$, $p=.013$, $d=0.28$. As in Study 1, this result was unaltered (this contrast remained significant) when controlling for age.[1]

Unexpectedly, this same contrast conducted on the search score of the MLQ revealed a marginally significant directionally similar pattern of results for search for meaning, with participants in the future condition ($M=4.82$, $SD=1.35$) and past condition ($M=4.90$, $SD=1.48$) reporting more search for meaning than participants in the present condition ($M=4.54$, $SD=1.53$), $t(312)=1.88$, $p=.06$, $d=0.21$. It is important to note, however, that search for meaning does not reflect absence of meaning, but rather a positive striving toward purpose that may be prompted by reflecting on the past or future (Steger et al., 2006).

Also unexpectedly, the same contrast conducted on word count, as a measure of how much participants wrote, revealed that participants wrote significantly more in the future condition ($M=119.27$, $SD=84.60$) and past condition ($M=205.01$, $SD=204.24$) than in the present condition ($M=113.13$, $SD=80.56$), $t(246.94)=3.72$, $p<.0001$, $d=0.47$. This effect was driven by participants in the past condition who wrote more than participants in either the future or present condition, $F(2, 312)=15.02$, $p<.0001$, $\eta_p^2=.09$. However, word count was not significantly correlated with presence of meaning ($r=.03$; $p>.61$) and was only marginally correlated with search for meaning, $r(313)=.098$, $p=.084$. In addition, controlling for word count by conducting the same regression analysis as we did with age, shows that the effect of condition on meaning remains significant ($\beta=-.14$, $t(311)=2.45$, $p=.015$); the significance of the ANCOVA for the effects of condition covarying word count remains unaffected as well ($F(2, 311)=3.02$, $p=.05$, $\eta_p^2=.02$). Therefore, it is unlikely that simply writing more influenced perceptions of meaning in life.

Given the findings of Study 1—that emotion-focused positive rumination was correlated with both connectivity in the MTL subsystem (a network ostensibly implicated in simulation) and meaning in life—and given prior research demonstrating the relationship between meaning in life and positive affect (King et al., 2006), we conducted an exploratory analysis to examine the relationship between affect and meaning in life. To analyze the affective content of participants written responses to the condition prompts, we used the

[1]We created two new condition variables, one that coded future as −1, past as −1, and present as 2 (to reflect the planned contrast), and one that coded future as 1, past as −1, and present as 0 (to reflect separate conditions), and regressed presence of meaning simultaneously on these two variables and age (per Hayes, 2013). The condition variable reflecting the planned contrast remained significant, $\beta=-.11$, $t(301)=2.05$, $p=.042$ (degrees of freedom are slightly lower because of participants who did not report age).

linguistic inquiry word count (LIWC) program (Pennebaker, Booth, & Francis, 2007), which determines the frequency of words related to positive emotions and the frequency of words related to negative emotions. Neither of these frequencies correlated significantly with presence of meaning in life ($r(313)=-.03$, $p=.60$;$r(313)=.08$, $p=.18$) suggesting affect was not driving these results. In addition, frequency of positive emotion did not differ significantly by condition ($F(2, 312)=0.11$, $p=.90$, $\eta_p^2=.001$). Negative emotion, however did differ significantly, $F(2, 312)=5.90$, $p=.003$, $\eta_p^2=.04$, such that negative emotion was highest in the past condition ($M=1.58$, $SD=1.92$), lowest in the future condition ($M=0.81$, $SD=1.31$), and planned contrasts showed that the past condition differed significantly from the future condition ($t(312)=3.36$, $p=.001$, $d=0.38$), but not from the present condition ($M=1.35$, $SD=1.58$) ($t(312)=1.03$, $p=.30$, $d=0.12$). Thus, the discrepancy in emotion produced by the past and future conditions suggests that temporal simulation in this study does not simply orient people toward specifically positive (or negative) events. Finally, controlling for positive emotion or negative emotion by conducting the same regression analysis as we did with age, shows that the effect of condition on meaning remains significant ($\beta=-.14$, $t(311)=2.51$, $p=.013$;$\beta=-.14$, $t(311)=2.56$, $p=.011$); the significance of the ANCOVA for the effects of condition covarying positive emotion or negative emotion remains unaffected as well ($F(2, 311)=3.19$, $p=.042$, $\eta_p^2=.02$; $F(2, 311)=3.28$, $p=.039$, $\eta_p^2=.02$).

To probe the nature of these events further, two research assistants (both blind to all hypotheses and conditions) coded participants' two written events on profundity (1=not at all profound to the participant; 6=very profound to the participant), level of detail of the descriptions of the events (1=not at all detailed; 6=very detailed), and valence of the descriptions (1=very negative; 6=very positive) (11 participants were excluded for producing uninterpretable, and therefore, uncodable, responses). Intraclass correlations were high for all events and ratings ($\alpha s \geq .65$, $ps<.0001$) so we averaged across events and raters, to produce composite scores of profundity, detail, and valence.

We conducted the same contrast as above on these evaluations, and found that each variable differed significantly across condition. Participants wrote about significantly more profound events in the in the future condition ($M=4.50$, $SD=0.96$) and past condition ($M=4.16$, $SD=0.99$) compared to the present condition ($M=2.15$, $SD=0.80$), $t(301)=19.71$, $p<.0001$, $d=2.27$. Participants wrote significantly more detailed descriptions in the in the future condition ($M=3.42$, $SD=0.87$) and past condition ($M=4.06$, $SD=0.90$) compared to the present condition ($M=3.31$, $SD=1.03$), $t(301)=3.83$, $p<.0001$, $d=0.44$. Participants also wrote more positively in the future condition ($M=4.17$, $SD=0.98$) and past condition ($M=3.60$, $SD=1.17$) compared to the present condition ($M=3.36$, $SD=0.56$), $t(294.32)=5.70$, $p<.0001$, $d=0.66$. Coding the future and past conditions as "1" and the present condition as "0," we used Hayes' (2013) PROCESS macro (bias-corrected, 20,000 resamples) to conduct a bootstrapping mediation analyses to determine whether these three variables (entered simultaneously) mediated the relationship between condition and presence of meaning. Profoundness (95% CI for indirect effect=0.09 to 0.80; 95% CI for total indirect effect=0.07 to 0.79) mediated the effect of condition on meaning, suggesting that considering the past and future increased people's focus on profound and positive events, thus increasing meaning in life. Valence (95% CI for indirect effect =−0.05 to 0.12) did not mediate this effect, nor did detail (95% CI for indirect effect=−0.15 to 0.01). Further inspection of detail revealed that the failure to mediate was likely a result of detail increasing in the past condition but not the future condition. Planned contrasts revealed that detail was greater in the past condition versus the present condition ($t(301)=5.77$, $p<.0001$, $d=0.67$), but detail did not differ between the future and present conditions ($t(301)=0.87$, $p=.39$, $d=0.10$). This pattern of results mimics the differences in word count between condition, and is to be expected given that people are likely more capable of writing in detail about things that have actually happened (in the past) versus those that have not yet happened (in the future).

In sum, considering the past or future compared to the present, increased meaning in life. Although automated linguistic coding did not reveal meaningful effects of word count or emotion on this pattern, independent human coding revealed that considering the past or future compared to the present led participants to write in more detail and about more profound and positive events. The profundity of participants' descriptions mediated the effect of condition on perceived meaning. These findings suggest that asking people to engage in momentary temporal simulation leads people to conjure up meaningful events, leading to a more global sense of meaning. Indeed, participants in our past and future conditions did seem to produce meaningful events, such as "I was in Fort Hood Texas, going through a Medical processing to prepare for Deployment to Iraq" (past) or "I will get married to the love of my life" (future).

Whereas previous work has asked people to recall specifically meaningful events (Routledge, Arndt et al., 2011; Routledge, Wildschut, Sedikides, Juhl, & Arndt, 2012), the present work shows that, when asked to recall events with no additional prompt, people spontaneously generate meaningful events. In addition, no previous work has demonstrated, as we have here, that experimental manipulations of prospection lead people to generate meaningful events. The present work thus expands on previous work to show that momentary directed temporal simulation leads people to perceive enhanced meaning in life through the generation of meaningful events. Given that level of detail followed a similar pattern as meaning, but did not explain the effect of condition on meaning (because of the dominance of detail in the past versus future condition), we explore detail and specificity in a more systematic fashion in the following study.

Study 3

Following from the correlation between MTL connectivity and meaning in Study 1, as well as previous research demonstrating the role of the MTL network and temporal simulation, Study 2 showed that simulating the past or future, compared to considering the present, enhanced perceptions of meaning in life. As noted above, the MTL network is particularly engaged for detailed versus gist-based simulation (Addis, et al., 2011; Holland et al., 2011; Levine et al., 2004; Nadel & Moscovitch, 1997; Viard et al., 2012). Furthermore, in Study 2, level of detail (as coded by independent observers) followed the same pattern as self-reported meaning in life. Detail increased when participants wrote about temporally distant (versus temporally near) events. Because we did not specifically design Study 2 to manipulate detail and did not account for naturally occurring differences in ability to describe the past versus future in detail, we sought to pursue this pattern further in the present study. Therefore, Study 3 manipulates detail explicitly to test the hypothesis that simulating the past or future in detail will enhance meaning compared to simulating the gist of past or future events.

Method

Our sample included two hundred ninety-one people (113 female, 175 male, 3 unreported, M_{age}=27.22, *SD*=9.22) who were recruited from MTurk and completed the study in full using Qualtrics software as in Study 2.

Participants were randomly assigned to write about the past or the future either in a detailed or gist-based manner, generating a 2 (temporal focus: past vs. future) X 2(description type: detailed vs. gist) design. In each of four conditions (past/detailed, future/detailed, past/gist, future/gist), participants were asked to describe either past or future events in detail or in a few words—this method of inducing a detailed versus gist-based orientation was adapted from previous work (Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002; Rudoy, Weintraub, & Paller, 2009). In particular, participants assigned to write about the past in detail were told to write separately about two discrete events that occurred 10 to 30 years ago “in as much detail as possible.” Participants assigned to write about the past in a gist-based manner were asked to generate nine discrete events that occurred 10 to 30 years ago and to describe each event using “one or two words apiece.” Participants assigned to write about the future in detail were told to write separately about two discrete events that would occur 10 to 30 years from now “in as much detail as possible.” Participants assigned to write about the future in a gist-based manner were asked to generate nine discrete events that would occur 10 to 30 years from now and to describe each event using “one or two words apiece” (in the future conditions, wording was altered slightly halfway through the experiment to correct for a typographical error, but this alteration did not meaningfully affect results). Following this manipulation of temporal focus and description type, participants completed the MLQ and reported demographic information as in the previous study.

Results

A 2(temporal focus: past vs. future) X 2(description type: detailed vs. gist) ANOVA was conducted on presence of meaning and search for meaning. For presence of meaning, no interaction or main effect for temporal focus emerged ($F(1, 287)=0.00$, $p=.99$, $\eta_p^2=.000$; $F(1, 287)=0.05$, $p=.83$, $\eta_p^2=.000$). However, as predicted, a main effect of description type emerged such that participants who described events in detail reported more presence of meaning (*M*=4.67, *SD*=1.34) than participants who described events in a gist-based manner (*M*=4.27, *SD*=1.44), $F(1, 287)=5.93$, $p=.015$, $\eta_p^2=.02$ (as in Study 2, controlling for age did not alter significance; $F(1, 283)=5.27$, $p=.022$, $\eta_p^2=.02$). No main effects or interactions emerged for analyses on search for meaning (all *F*s<.88, *p*s>.35, η_p^2s≤.003).

A similar 2(temporal focus: past vs. future) X 2(description type: detailed vs. gist) ANOVA was conducted on word count and revealed main effects for temporal focus, $F(1, 287)=28.20$, $p<.0001$, $\eta_p^2=.09$, and description type, $F(1, 287)=246.38$, $p<.0001$, $\eta_p^2=.46$, qualified by a temporal focus X description type interaction, $F(1, 287)=27.83$, $p<.0001$, $\eta_p^2=.09$. Participants in the past/detailed condition wrote significantly more ($M=157.51$ $SD=102.21$) than participants in the future/detailed condition ($M=86.54$ $SD=54.25$), and participants in the past/detailed and future/detailed conditions wrote more than participants in the past/gist ($M=16.91$ $SD=4.24$) condition and future/gist condition ($M=16.67$ $SD=7.72$), respectively (ts>10.14, ps<.0001, ds>2.53). Participants in the past/gist and future/gist conditions did not significantly differ in word count ($t(128.22)=0.24$, $p=.81$, $d=.04$). Despite these differences, as in Study 2, word count was not meaningfully correlated with presence of meaning or search for meaning (rs<[.07], ps>.29), so it is unlikely that increased writing alone contributed to meaning in life. Furthermore, entering word count as a covariate in a 2(temporal focus: past vs. future) X 2(description type: detailed vs. gist) ANCOVA did not alter the significance of the main effect of description type, $F(1, 286)=5.67$, $p=.018$, $\eta_p^2=.02$.

The findings of Studies 2 and 3 suggest that the conceptual detail with which participants wrote rather than word count per se appears to have affected meaning in life. In Study 2, all participants were asked to write in detail, and writing about the past and future in detail enhanced meaning in life compared to writing about the present in detail. In the present study, being asked to write about the past or future in detail compared to being asked to write about the past or future in a gist-based fashion enhanced meaning in life.

As in Study 2, we conducted exploratory analyses on frequency of positive and negative emotion (coded by LIWC), and again, neither of these frequencies correlated significantly with meaning in life ($r(289)=-.02$, $p=.71$; $r(289)=-.10$, $p=.11$). In addition, we conducted a 2(temporal focus: past vs. future) X 2(description type: detailed vs. gist) ANOVA on both frequencies. For positive emotion, no main effect of temporal focus emerged ($F(1, 287)=0.01$, $p=.95$, $\eta_p^2=.000$), suggesting that past versus future thinking did not affect positive affect. Interestingly, a main effect of description type emerged such that positive emotion was more frequent in the gist ($M=5.64$, $SD=10.63$) versus detailed ($M=3.18$, $SD=2.62$) condition, $F(1, 287)=6.80$, $p=.01$, $\eta_p^2=.02$, and this effect was marginally qualified by a temporal focus X description type interaction ($F(1, 287)=2.94$, $p=.088$, $\eta_p^2=.01$) such that this pattern was more prominent in the past condition. For negative emotion, no interaction emerged ($F(1, 287)=0.00$, $p=1$, $\eta_p^2=.000$), but main effects for type and temporal focus did ($F(1, 287)=3.75$, $p=.054$, $\eta_p^2=.01$; $F(1, 287)=7.19$, $p=.01$, $\eta_p^2=.02$). Negative emotion was more frequent for gist-based ($M=1.88$, $SD=4.77$) versus detailed ($M=1.22$, $SD=1.29$) descriptions (like positive emotion), and was more frequent for past ($M=2.05$, $SD=3.19$) versus future ($M=1.10$, $SD=3.13$) descriptions. Overall, these findings point to an inconsistent relationship between meaning in life and affect across conditions, and the nonsignificant correlation between affect frequencies and meaning suggests that, the results from Study 3 do not simply result from simulation orienting people toward specifically positive or negative events. Unlike Study 2, coding these responses would not yield meaningful results because of differences in word count and grammatical structure across condition, so it is not clear whether other measures of valence would emerge differently across condition.

It is perhaps unsurprising that ruminating more specifically versus generally on temporally distant events enhances meaning. Indeed, as in Study 2, participants in the detailed condition appeared to generate ostensibly meaningful events (e.g., “18 years ago my son was born”). These results are nontrivial for at least three reasons. First, if leading people to describe temporally distant events induces them to generate profound events (as in Study 2), *a priori* it is just as likely that generating more of these events will increase perceived meaning compared to focusing specifically on two of these events. Second, these findings provide further utility for Study 1, confirming a hypothesis explicitly derived from Study 1’s neural results that the MTL network—a network known to be involved in detailed (rather than general) simulation—is associated with enhanced meaning. Third, these findings provide a novel contribution to the literature on psychological distance, supporting the idea that distance is not additive. Just as one set of studies showed presenting people with an initially social, spatial, temporal, or probabilistic distance reduced sensitivity to a second distance in choice and decision-making contexts (Maglio, Trope, & Liberman, 2012), the present study demonstrates that asking people to describe temporally distant events in a distal (i.e., gist-based) fashion reduced, rather than increased, meaning.

Studies 1–3 revealed the relation between detailed temporal simulation and meaning in life. Previous literature has established a connection between MTL activity and simulation in the domain of temporal simulation. However, our hypotheses propose that simulation *in general*, rather than temporal simulation specifically, should affect presence of meaning in life. As such, subsequent studies aimed to replicate and expand the generalizability of these findings in a different domain of simulation: spatial simulation.

Study 4

The purpose of Study 4 was fourfold. First, we sought to examine the effects of a separate form of simulation closely linked to temporal simulation on meaning—spatial simulation. If simulation in general is linked to meaning, and different forms of psychological distance operate similarly (Liberman & Trope, 2003; Liberman & Trope, 2010), then spatial simulation—particularly detailed spatial simulation—should enhance meaning compared to considering one’s present location. Second, we sought to expand on the findings of the previous study to compare detailed and gist simulation to detailed rumination on the present. Third, following from Study 2, which revealed a link between the profoundness of events generated and perceived meaning, we examined the effect of simulation on people’s own perceptions of the meaningfulness of events they generate (event-derived meaning). Finally, we provided an initial examination of the role of nostalgia and hope in simulation and meaning. Unlike Study 2, this Study (and Studies 5 and 6) asks about people’s interpretations of the events they generate, and thus do not rely on independent human coding or automated coding.

Method

Our sample included four hundred and eighty people (212 female, 267 male, 1 unreported, M_{age}=32.01, SD=10.62) who were recruited from MTurk and completed the study in full using Qualtrics software as in Studies 2–3.

Participants were randomly assigned to write about their present location in a detailed fashion (present/detailed condition), an alternate location in a detailed fashion (elsewhere/detailed condition), or an alternate location in a gist-based fashion (elsewhere/gist condition). In the present/detailed condition, participants were asked to think about and describe "an event that is happening to you today in your current location" and were asked to "describe this event in as MUCH DETAIL AS POSSIBLE, in at least 250 characters." Instructions also read, "What are the sights, sounds, or smells you experience during this event? What emotions do you feel during this event? Feel free to get creative and envision any event that might happen to you today in your current location." Participants were then asked to describe in detail a second event happening today in their current location and after these two descriptions, were asked to indicate their current location. In the elsewhere/detailed condition, participants were given similar instructions to write about two events in as much detail as possible, but instead of being asked to imagine and write about an event in their current location, they were asked to "imagine an event happening to you today in a different location other than the one where you currently are" and to "feel free to get creative and envision any event that might happen to you today in this alternate location." As in the present/detailed condition, participants were asked to indicate what this alternate location was. In the elsewhere/gist condition, participants were asked to "imagine nine events happening to you today, but happening to you in a different location other than the one where you currently are. Please imagine any nine, discrete episodes happening to you in this alternate location. As in the gist condition from Study 3, participants were asked to describe each of these events using one or two words apiece." Participants also indicated what the alternate location was that they were describing.

Next, participants answered six questions on a 7-point scale (1=not at all to 7=very much) about their perceived meaning of the events they just described. Two items apiece tapped into each of three fundamental facets of meaning (Heintzelman & King, 2014a; 2014b): Purpose ("To what extent do the events that you described involve achieving a purposeful goal?"; "To what extent are the events that you described full of purpose?"), Significance ("To what extent do the events that you described make you feel significant?"; "To what extent are the events that you described important rather than trivial?"), and Coherence ("To what extent do the events that you described give you a sense of coherence?"; "To what extent do the events you described make sense?"). These items constituted a highly reliable composite (α=.75) so we averaged these items to produce a measure of event-derived meaning. Participants then also completed in a counterbalanced order set of measures to examine affect: the 20-item Positive and Negative Affect Schedule (PANAS) (Watson, Clark, & Tellgen, 1988) to assess current mood, and two items on a 7-point scale (1=not at all to 7=very much) "To what extent did you experience hope during the writing exercise in the previous section?" and "To what extent did you experience nostalgia during the writing exercise in the previous section?"

Results

We first examined the effects of condition on the meaning of events, and an omnibus comparison of meaning between condition revealed a significant overall effect, $F(2, 477)=9.00$, $p<.0001$, $\eta_p^2=.04$. Age was correlated with meaning, $r(478)=.18$, $p<.0001$, but controlling for age did not alter significance of this effect[2]. Subsequent planned contrasts comparing conditions revealed that participants in the elsewhere/detailed condition reported more meaning (M=4.99, SD=1.31) than participants in the here/detailed condition (M=4.49, SD=1.35) and reported more meaning than participants in the elsewhere/gist condition (M=4.38, SD=1.29) (ts>3.21, ps≤.001, ds>0.29). The here/detailed condition and elsewhere/gist condition did not differ significantly ($t(477)=0.77$, $p=.44$, $d=0.07$). Thus, as predicted, detailed simulation of an alternate place led participants to derive more meaning from the events they considered.

A similar omnibus analysis on word count revealed a significant effect of condition, $F(2, 477)=223.52$, $p<.0001$, $\eta_p^2=.48$, and similar planned contrasts revealed that our manipulation was effective. No significant differences emerged between the here/detailed (M=210.10, SD=126.76) and elsewhere/detailed (M=217.21, SD=124.59) conditions ($t(281.24)=0.48$, $p=.63$, $d=0.06$), but both detailed conditions differed significantly from the elsewhere/gist condition (M=20.40, SD=13.29) (ts>18.14, ps<.0001, ds>3.13). Interestingly, word count was correlated with meaning, $r(478)=.16$, $p=.001$, yet, as with age, controlling for word count did not alter the significance of the overall effect[3].

Comparable omnibus analyses on positive and negative affect measured through the PANAS revealed no significant effects (Fs<.32, ps>.41, η_p^2s≤.001), yet significant effects did emerge for hope and nostalgia. Omnibus analyses revealed that both hope and nostalgia differed significantly across conditions ($F(2, 477)=9.81$, $p<.0001$, $\eta_p^2=.04$ and $F(2, 477)=10.01$, $p<.0001$, $\eta_p^2=.04$). Planned contrasts also revealed significant results mirroring the pattern found with meaning. Hope was greater for participants in the elsewhere/detailed condition (M=4.65, SD=1.89) than participants in the here/detailed condition (M=3.87, SD=1.82) and in the elsewhere/gist condition (M=3.76, SD=1.88) (ts>3.54, ps≤.001, ds>0.32). Nostalgia was also greater for participants in the elsewhere/detailed condition (M=4.28, SD=2.03) than participants in the here/detailed condition (M=3.44, SD=1.92) and in the elsewhere/gist condition (M=3.36, SD=1.92) (ts>3.66, ps<.0001, ds>0.33). Thus, although we directed participants to write about “today” rather than the past or future, when they considered events in alternate locations specifically, they experienced temporally oriented emotions of nostalgia and hope. This result is consistent with other research demonstrating links between spatial simulation and temporal simulation (Casasanto & Boroditsky, 2008; Trope & Liberman, 2010; Tamir & Mitchell, 2011).

Overall, Study 4 demonstrates an alternate form of simulation—spatial simulation—increases event-derived meaning, and detailed spatial simulation enhances meaning compared to detailed consideration of the present or gist-based spatial simulation. In addition, detailed spatial simulation also increased temporally oriented positive emotions, nostalgia and hope, compared to detailed consideration of the present or gist-based spatial

[2]Similar to Study 2, we created two new condition variables, one that coded here/detailed as −1, elsewhere/gist as −1, and elsewhere/detailed as 2 (to reflect a planned contrast between the condition of interest, elsewhere/detailed, and the two other conditions), and one that coded elsewhere/gist as 1, here/detailed as −1, and there/detailed as 0 (to reflect separate conditions), and regressed presence of meaning simultaneously on these two variables and age (per Hayes, 2013). The condition variable reflecting the planned contrast remained significant, $\beta=.18$, $t(477)=3.94$, $p<.0001$.

[3]An identical analysis as described in Footnote 2 that included word count instead of age as a predictor variable revealed that condition variable reflecting the planned contrast remained significant, $\beta=.15$, $t(477)=3.13$, $p=.002$.

simulation. Although our manipulation of detailed spatial simulation included instructions to focus on the present, participants appeared to generate events that brought to mind positive emotion related to the past and the future. In conjunction with Studies 1–3, these findings add to existing research on simulation and psychological distance to demonstrate that not only do different forms of simulation (temporal and spatial) operate through similar mechanisms (Buckner & Carroll, 2007; Liberman & Trope, 2003; Liberman & Trope, 2010; Tamir & Mitchell, 2011), but they have similar consequences for meaning in life as well.

The findings from Study 4 also replicate analyses in Study 2, which showed that when people simulate distal events, they are more likely to simulate events that are profound and meaningful. Study 2 demonstrated this effect in the domain of temporal simulation, where past and future events were more meaningful than current events. The findings from the current study suggest that spatial simulation is likewise conducive to generating meaningful events, suggesting that the previous findings were not merely a function of the fact that peoples' most salient or accessible retrospections and prospections are also their most meaningful; it did not necessarily have to be the case that people would generate more meaningful events when simulating themselves far away versus in their current location. Together, these findings suggest a possible mechanism for how simulation may enhance meaning in life, which we test in the following study: simulation enhances the meaning derived from events people generate, which results in increased meaning in life in general.

Study 5

The goals of Study 5 were three fold. First, we sought to build upon findings from Study 2 to show that spatial simulation (not just temporal simulation) increases meaning in life in general (and not event-derived meaning). Second, we sought to replicate the findings of Study 4 to show that spatial simulation (compared to focusing on one's present location) increases meaning derived from the events people generate. Finally, we examined whether event-derived meaning might serve as a mediator that accounts for why simulation enhances meaning in life in general.

Method

Our sample included three hundred seventy-seven people (157 female, 218 male, 2 unreported, M_{age}=31.56, *SD*=11.14) who were recruited from MTurk and completed the study in full using Qualtrics software as in Studies 2–4.

Participants completed demographic items and then were randomly assigned to write about their present location (here-condition) or to write about an alternate location (elsewhere-condition), in at least 250 characters. Participants in the here-condition were told:

> Please take a moment to think about your present location and what you were doing one hour ago, *today*. Take a minute to think of the event that was occurring an hour ago and then describe the event that occurred an hour ago, in detail, in the space below.

Participants in the elsewhere-condition were told:

> Please take a moment to imagine yourself *today* in a location that is different from the one you are in now. Think of any location you like that is not your present location, and imagine being there. Take a minute to think about being in that location and imagine what you were doing an hour ago in that alternate location. Then describe the event that occurred an hour ago in that alternate location, in detail, in the space below.

We constrained the writing task to have participants write about an event one hour ago so we could ensure that participants were writing within a similar timeframe, within the current day. Next participants completed three items assessing the meaning they derived from the events they described (with each item indexing one of the three components of meaning—coherence, significance, and purpose): "To what extent does the event that you described give you a sense of coherence?," "To what extent does the event that you described seem important rather than trivial?," and "To what extent does the event that you described give you purpose?" (1=not at all to 7=very much). We averaged these items to form a composite score of event-derived meaning (α=.75). Following these items, participants answered one question on the same scale examining meaning in life in general: "To what extent do you feel your life has meaning?" Then, participants completed the PANAS as in the previous study, and answered the items assessing nostalgia and hope from the previous study as well as an equivalent item assessing awe ("To what extent did you experience awe during the writing exercise in the previous section?"). We measured awe because of its potential relationship both to self-projection beyond the here and now and experiences of meaning. Recent research has demonstrated an association between the expanded perception of time and feelings of awe (Rudd, Vohs, & Aaker, 2012), an emotion that generates the feeling of being part of a vast and purposeful universe (Keltner & Haidt, 2003; Valdesolo & Graham, 2013). As in previous studies, our primary hypothesis was that simulation—in this case considering an alternate location compared to considering an event in one's present location—would enhance meaning.

Results

Most important to our hypothesis, independent samples *t*-tests revealed that elsewhere-condition participants compared to here-condition participants derived more meaning from the events they generated (*M*=4.81, *SD*=1.37 vs. *M*=4.05, *SD*=1.55), *t*(375)=5.03, *p*<.0001, *d*=0.52, and experienced more meaning in life (*M*=5.07, *SD*=1.72 vs. *M*=4.51, *SD*=1.87), *t*(375)=3.04, *p*=.003, *d*=0.31. Age was correlated with both of these variables (*r*s>.14, *p*s≤.005), but controlling for age in regressions predicting event-derived meaning and general meaning from age and condition did not alter significance of condition's effect in either case (β=.24, *t*(374)=4.92, *p*<.0001; β=.15, *t*(374)=2.92, *p*=.004). Word count did not differ significantly across condition (*t*(375)=1.16, *p*=.25, *d*=0.12). Interestingly, word count was significantly correlated with meaning of events and general meaning (*r*s>.11, *p*s<.025), but entering word count as a covariate in one-way ANOVA tests on these items did not alter significance (*F*s≥8.52, *p*s≤.004, η_p^2s>.02).

We also conducted *t*-tests across condition on the positive and negative affect subscales of the PANAS, and measures of hope, nostalgia, and awe. Positive affect did not differ by condition (*t*(375)=1.18, *p*=.24, *d*=0.12) whereas negative affect did such that elsewhere-condition participants reported less negative affect than here-condition participants (M=13.22, SD=5.91 vs. M=14.51, SD=7.22), $t(372.14)=1.89$, $p=.059$, $d=0.20$. Negative affect, however, was not correlated with meaning derived from events ($r(375)=-.07$, $p=.19$), and therefore will not be discussed further. Tests comparing conditions on hope (M=4.31, SD=2.02 vs. M=2.82, SD=1.84; $t(375)=7.52$, $p<.0001$, $d=0.78$), nostalgia (M=4.38, SD=2.15 vs. M=2.70, SD=1.80; $t(346.82)=8.18$, $p<.0001$, $d=0.88$), and awe (M=3.54, SD=1.97 vs. M=2.23, SD=1.71; $t(352.14)=6.87$, $p<.0001$, $d=0.73$) revealed that spatial simulation compared to present-focused thinking increased each of these emotions as well. All of these emotion items were correlated with both event-derived meaning, and meaning in general (rs>.34, ps<.0001).

Thus, these findings replicate and extend the results of Study 4. Again, we find that despite being asked to simulate an event today in an alternate location, participants who engage in spatial simulation experience greater temporally oriented emotions—nostalgia and hope—compared to participants who focus on their present location. In addition, we find that awe, an emotion associated both with mental simulation and the experience of meaning, follows the same pattern.

Coding the elsewhere-condition as “1” and the here-condition as “0,” we used Hayes’ (2013) PROCESS macro (bias-corrected, 20,000 resamples) we conducted a bootstrapping mediation analyses to test whether event-derived meaning, hope, nostalgia, and awe[4] (entered simultaneously) accounted for the effect of condition on meaning in life in general. Event-derived meaning appeared to mediate this effect (95% CI for indirect effect=0.20 to 0.58; 95% CI for total indirect effect=0.47 to 0.95), but awe (95% CI for indirect effect= −0.15 to 0.17), nostalgia (95% CI for indirect effect=−0.05 to 0.32), and hope (95% CI for indirect effect=−0.0001 to 0.46) appeared not to mediate the effect as indicated by the indirect effect of each one showing a 95% confidence interval that included “0.” This finding provides evidence consistent with Study 2 for a mechanism driving simulation’s effect on meaning in life: projecting oneself beyond the here and now facilitates the generation of meaningful events, which in turn enhances meaning in life.

We wish to pause here to note that although this finding seems almost tautological—that generating meaningful events would lead people to experience meaning generally—a clear alternative hypothesis exists, which is that the generation of meaningful events would decrease people’s feelings of meaning generally. Evidence for this alternative hypothesis is multifold. First, studies have shown that asking people to reflect on the happiness of a single event (e.g., marriage) leads them to subsequently “subtract” this experience from reports of happiness with their life in general (Schuman & Presser, 1981; Schwarz, 1999; Tourangeau, Rasinski, & Bradburn, 1991). Others have shown that, reflecting on the presence of a positive and meaningful event in one’s life (compared to reflecting on the absence of such an event) reduced or failed to alter general positive feelings (Koo et al., 2008). In addition, participants in the present study’s elsewhere-condition were specifically asked to generate hypothetical events (events occurring today, but elsewhere) that, if meaningful, could lead

[4]Although these emotions are measured after meaning in life, the measures pertain to emotions experienced during the generation of the event, and therefore could account for primary effect of condition on meaning in life.

them through a contrast effect to infer that their current experience of meaning in general lacks the meaning they derived from that self-generated event. Of course, some participants in the present study undoubtedly drew on personal experiences to generate these hypothetical events (e.g., one participant wrote, “I am outside walking with my husband on our mountain property”). Nonetheless, we believe the sum of these factors suggests that the present finding is novel and not overly intuitive.

In sum, Study 5 suggests that spatial simulation compared to considering one’s present location enhances meaning in life through facilitating the generation of event-generated meaning, and the generation of these events produce, hope, awe, and nostalgia as well. In a final study, we examine whether a more minimal manipulation of spatial simulation can similarly enhance meaning in life.

Study 6

The purpose of Study 6 was twofold. First, we aimed to replicate the findings of Studies 4–5 using a minimal manipulation of spatial simulation. In this study, we simply ask people to answer questions related to meaning in life either as if they were in an alternate location, or as if they were in their current location. Doing so provides an additional clear test of the effect of spatial simulation, given that in Study 5, participants not only simulated spatially, but also to a small extent, temporally (in that they thought about an event that took place one hour ago). Second, in Study 5, we measured meaning in life using a 1-item question. To provide converging evidence for our effect, in the present study, we use an additional measure derived from the well-validated meaning in life questionnaire (Steger et al., 2006). We hypothesized that simply bringing participants into a spatially distant mindset would enhance feelings of meaning. We adapted this procedure from studies asking people to imagine being in a spatially distant versus spatially near location (Fujita, Henderson, Eng, & Trope, 2006). Importantly, we did not expect that asking participants merely to imagine completing a questionnaire in an alternate location would have an overly large effect on self-reported meaning in life. Yet, given the subtlety of the manipulation, we view the current study as a conservative test of our theoretical account.

Method

Given the minimal nature of our manipulation in this study, we expected a larger sample would be required to detect an effect. Therefore, our sample included seven hundred and six people (344 female, 462 male, M_{age}=30.95, SD=9.94) who were recruited from MTurk and completed the study in full using Qualtrics software as in Studies 2–5.

Participants answered demographic questions and then were randomly assigned to one of two conditions, here or elsewhere. In the here-condition, participants were asked to imagine being in their present location, specifically today:

> Please take a moment to think about today being in your present location. Take a moment to think about what your location is like, and what your surroundings are. When you have taken a moment to think about your present location, please write the name of your location in the space below.

In the elsewhere-condition, designed to induce spatial simulation, participants were asked to imagine being in a *different* location than their present location, specifically today:

> Please take a moment to imagine today being in a different location than the one in which you presently are. Take a moment to think about what that alternate location is like, and what your surroundings are. When you have taken a moment to imagine what it is like to be in that alternate location, please write the name of that location in the space below.

All participants then completed four questions adapted from the meaning in life questionnaire (Steger et al., 2006) on a 7-point scale (1=Strongly Disagree, 7=Strongly Agree): "Would you say your life has meaning?,""Would you say your life has a clear sense of purpose?," "Would you say you have a good sense of what makes your life meaningful?," and "Would you say you have discovered a satisfying life purpose?" In the here-condition each of these questions was preceded by the stem, "Considering yourself in your present location," where as in the elsewhere-condition each question was preceded by the stem, "Imagining yourself in this alternate location." In addition, participants in the here-condition were asked to answer the questions "while doing so in your present location. How do you feel in your present location today?" Participants in the elsewhere-condition were asked to answer the questions "while imagining you are doing so in the alternate location you described above. How do you feel imagining being in this alternate location today?" These items constituted a highly reliable composite (α=.94) so we averaged these items to produce a measure of perceived meaning.

Participants then completed the PANAS and questions about hope, nostalgia, and awe, as in Study 5, with here-condition participants being asked to do so while considering their present location and elsewhere-condition participants being asked to do so while imagining their alternate location. As in previous studies, our primary hypothesis was that spatial simulation compared to consideration of one's present location, would increase reports of meaning in life.

Results

Most important to our hypothesis, independent samples *t*-tests revealed that elsewhere-condition participants compared to here-condition participants reported more meaning in life (M=4.65, SD=1.47 vs. M=4.44, SD=1.45), $t(704)$=1.89, p=.059, d=0.14. As noted above, with such a subtle manipulation, it is unsurprising that the effect size of this study is relatively small. Age was correlated with meaning, $r(704)$=.12, p=.002, and appeared to differ across condition (M=31.64, SD=10.56 vs. M=30.28, SD=9.26), $t(686.59)$=1.83, p=.068, d=0.14. However, controlling for age in a regression predicting meaning from age and condition reduced the effect of condition only to marginal significance (β=.06, $t(703)$=1.69, p=.092), suggesting that age did not fully account for the effect of condition. Overall, we acknowledge that this effect is smaller than that observed in Studies 1–5, but nonetheless is consistent with our hypothesis and provides converging evidence with a minimal manipulation of simulation.

We conducted similar *t*-tests on the positive and negative affect subscales of the PANAS, and measures of hope, nostalgia, and awe. Both positive affect and negative affect differed by condition such that elsewhere-condition participants reported more positive affect (M=31.76, SD=9.29 vs. M=27.70, SD=8.64; $t(704)$=6.02, p<.0001, d=0.45) and less negative affect (M=13.35, SD=5.46 vs. M=14.61, SD=6.86; $t(677.60)$=2.71, p=.007, d=0.21) than here-condition participants. Tests comparing conditions on hope (M=4.51, SD=1.94 vs. M=2.39, SD=1.54; $t(661.51)$=16.02, p<.0001, d=1.25), nostalgia (M=4.79, SD=1.68 vs. M=4.07, SD=1.63; $t(704)$=5.76, p<.0001, d=0.43), and awe (M=4.52, SD=1.99 vs. M=2.81, SD=1.73; $t(658.08)$=12.17, p<.0001, d=0.95) revealed that spatial simulation compared to present-focused thinking increased each of these emotions as well.

Coding the elsewhere-condition as “1” and the here-condition as “0,” we again used Hayes’ (2013) PROCESS macro (bias-corrected, 20,000 resamples) to conduct a bootstrapping mediation analyses entering each emotion-related variable and PANAS subscale simultaneously. Each one emerged as a significant mediator on its own, except for awe (95% CI for indirect effect=−0.06 to 0.01), with a significant total indirect effect (95% CI=0.34 to 0.70). In other words, considering an alternate location compared to considering one’s present location increased meaning in life through increasing positive affect (95% CI for indirect effect=0.09 to 0.24), reducing negative affect (95% CI for indirect effect=0.02 to 0.11), increasing hope (95% CI for indirect effect=0.02 to 0.30), and increasing nostalgia (95% CI for indirect effect=0.13 to 0.33). These findings both replicate and extend the results of Studies 4–5. Using a very minimal manipulation of spatial simulation—asking participants to answer questions in either their current or a distant location—Study 6 suggests that spatial simulation compared to considering one’s present location enhances meaning in life. Consistent with prior research showing a link between positive affect and meaning (Hicks et al., 2006), simulation increased positive affect while decreasing negative affect. Consistent with research showing a link between hope and nostalgia and meaning (Feldman & Snyder, 2005; Routledge et al., 2013), simulation increased both hope and nostalgia. Just as Study 5 found that simulation increased meaningful events through the experience of event-derived meaning, in Study 6, simulation increased meaning in life through the experience of these meaningful emotions.

General Discussion

The present research uses diverse samples and methods (neuroimaging and online laboratory experiments) to provide novel evidence for a direct link between mental simulation and the presence of meaning in life. Researchers have long-considered these concepts to be intertwined, with at least one definition of meaning stating explicitly, “Lives may be experienced as meaningful when they are felt to have significance beyond the trivial or momentary” (King et al., 2006, p. 180). However, beyond demonstrating that specifically targeted forms of simulation (e.g., nostalgia and hope) produce meaning and that simulating perspectives or counterfactual alternatives enhances the meaning of specific events, research has not demonstrated definitively that undirected simulation corresponds to both enhanced perceived meaning of specific events and enhanced meaning *in general*. In addition, no research to our knowledge has demonstrated that spatial simulation increases experiences of meaning. Six studies here explicitly demonstrate a robust link between two types of mental simulation and enhanced meaning.

Study 1 shows that coherence in the neural network primarily involved in temporal simulation is linked to meaning in life. Study 2 demonstrates that whether people engage in temporal simulation or not influences meaning in life. Study 3 indicates that the *extent* to which people engage in temporal simulation influences meaning in life. These studies use the same measure of perceived meaning to provide converging evidence that the ability and tendency to get outside the here and now, and the specificity with which one does this is associated with enhanced meaning in life.

Notably, Study 1 showed that that greater connectivity (as measured during a passive resting task) in the MTL subsystem, the neural network associated with temporal simulation, was linked to greater presence of meaning in life. It remains an open question as to whether passive rest allows for measurement of connectivity as close as possible to the brain's underlying functional anatomy or whether passive rest operates like any other functional task, assessing what people do (and what the brain does) when they are otherwise unconstrained. Thus, there are at least two potential explanations for the correlation between heightened MTL subsystem connectivity and meaning in life: (1) this correlation results from natural individual variation in the strength of functional coherence between the various neuroanatomical structures in this subsystem, or (2) this correlation results from individual variation in the tendency to partake in psychological processes such as temporal simulation that engage the MTL subsystem during periods of "free thought." Future research (using fMRI), however, should examine whether tasks that are known to increase meaning in life preferentially recruit the neuroanatomical structures that are part of the MTL subsystem, and similarly, whether alterations in MTL subsystem activity (through transcranial magnetic stimulation or other methods) can blunt or enhance meaning in life.

Study 2 confirms that temporal simulation enhances meaning in life and Study 3 suggests that the effects of temporal simulation on meaning in life are modulated by the detailed versus general nature of the simulation, consistent with the functions of the MTL subsystem (Addis, et al., 2011; Holland et al., 2011; Levine et al., 2004; Nadel & Moscovitch, 1997; Viard et al., 2012). Of interest, in Studies 2 and 3, no meaningful difference emerged in perceptions of meaning in life between past versus future mental time travel, in accordance with prior work demonstrating effective similarity between prospection and retrospection (D'Argembeau & Van der Linden, 2006).

Importantly, data from Study 2 demonstrated an underlying mechanism for the link between simulation and meaning in life. Namely, when people simulate distal events, they are simply more likely to conjure events that are more profound and meaningful than when they simulate more proximal occurrences. In turn, simulating more profound events leads to a heightened sense of meaning in life. The results from Study 2 suggest that experiencing the present is simply not as subjectively profound or meaningful as mentally transporting oneself to the past or the future. Notably, the valence of events simulated did not serve as a mediator for the relationship between simulation and meaning in life.

Studies 4, 5, and 6 speak to the generalizability of these effects and examine spatial rather than temporal simulation. Specifically, these studies showed that participants who were asked to simulate being in alternate locations reported subsequent increases in meaning in life, as well as boosts in the perceived meaning of target events. Study 4 directly examined whether simulating an event in a different location led to an increased sense of meaning derived from the event itself, and Study 5 extended this result to meaning in life more generally. Study 6 employed a more minimal manipulation and found that participants who were asked to imagine completed the meaning in life questionnaire in an alternate location reported higher levels of meaning in life than those who imagined completing the questionnaire in their present location.

The findings from Study 4 also replicated an observation made in Study 2 regarding the profundity of self-generated events. Whereas Study 2 demonstrated that past and future events were more meaningful than current events, Study 4 revealed that spatial simulation is conducive to generating meaningful events as well. In Study 5, we found once again that simulation enhances the meaning derived from events people generate, which resulted in increased meaning in life in general. Although spatial simulation increased feelings of awe, hope, and nostalgia, a multiple mediation model suggested that none of these emotional states accounted for the relationship between simulation and increased meaning in life, whereas enhanced profundity did.

In Study 6, however, we do find that these emotions account for the relationship between spatial simulation and meaning in life. Note, though, that in Study 6, there was no event for participants to generate (in that they were simply imagining filling out the meaning in life questionnaire in an alternate location). As such, emotions such as awe, hope, and nostalgia may in a way be collinear with, or at least encompassed by the general meaning of an event itself. Given that simulation boosts awe, hope, and nostalgia and given that simulation also increases event-related meaning, it may simply be the case that awe, hope, and nostalgia are weaker mediators, and their effect will only be visible when they are not coupled with event-related meaning.

Other potential mechanisms for the effect of mental simulation on enhanced meaning may exist as well, two of which we not here to suggest avenues for future research. The first is derived from construal level theory. As noted in the introduction, this theory suggests that psychological distance engages people to process events abstractly such that they do not merely construe events in terms of their actions ("how" an event or behavior occurs), but rather in terms of their purpose ("why" an event or behavior occurs) (see also Vallacher & Wegner, 1987). Construing events in terms of their purpose might then potentially give individuals a greater sense of purpose in their own lives.

A second possible mechanism is that considering the past or future brings people closer to one's true self-concept, a known factor corresponding to meaning in life. One series of studies, for example, demonstrated that people who had greater accessibility of traits and qualities that reflected their true selves versus their actual selves reported greater meaning in life (Schlegel, Hicks, Arndt, & King, 2009). These studies defined the true self as traits that describe "who you believe you really are, even if you sometimes act in different ways" whereas they defined the actual self as the “everyday self” and as traits that describe “who you are during most of your daily activities, even if these traits don’t reflect who you really are” (Schlegel et al., 2009, p. 482). Notably, inherent in this distinction is that the actual self is more temporally bound to the present and more connected with one’s daily activities whereas the true self is less temporally constrained. Thus, with regard to the present studies, it is possible that simulating the past or the present allows people to transcend the day-to-day activities of one’s actual self, to focus on events related to one’s true self, a more potent source of meaning in life.

As for whether other forms of simulation might similarly enhance meaning also remains an open question for future research to explore. The present research focused on temporal and spatial simulation, but it is possible that other forms of simulation such as perspective-taking or hypothetical thinking similarly enhance meaning in life. If simulation, broadly speaking, enhances meaning, then inducing alternate forms of simulation should increase perceived meaning in life in the same fashion as considering the past or future. For example, future work could prompt people to focus on their personal egocentric perspective on a particular issue or to adopt the perspective of someone with a different point of view, to test whether stepping outside of oneself in this fashion enhances meaning. Similarly, asking people to engage in hypothetical thinking (e.g., imagining themselves as the opposite gender; Tamir & Mitchell, 2011) might also enhance meaning.

Some limitations of the current research provide opportunities for future work. The generalizability of our results, for example, is confined to a Western population, given that all of the current studies were conducted with samples of participants living in America. Given that citizens of poorer nations have higher levels of meaning in life than citizens of richer nations (Oishi & Diener, 2014), it is possible that the relationship between simulation and meaning in life may also differ by nation-wide income levels. Future work might also examine the link between simulation and meaning in life across multiple testing sessions, given that the two were always measured one after another in the current studies.

One final, related question for future research concerns whether constant simulation enhances meaning in life, or whether only occasional simulation increases perceived meaning. The present studies involve one-shot instances of intentional and attention-directed temporal simulation or measurements of simulation over a short time period. Sustained periods of unintentional and unattended spatial simulation and mental time travel might operate differently (Mason, Norton, Van Horn, Wegner, Grafton, & Macrae, 2007), given evidence that constant mind-wandering—experiencing spontaneous lapses in attention—negatively predicts happiness (Killingsworth & Gilbert, 2011) (although we also note that happiness is distinct from meaning in life; Baumeister et al., 2013). Future research can address whether frequent simulation affects meaning in life similarly or distinctly from the one-shot instances of directed temporal simulation in the present studies.

Beyond generating topics for future research, the current research has an important implication: simulating oneself beyond the present moment may go a long way toward bolstering feelings of meaning. This suggestion may seem counterintuitive in light of work showing the negative effects of directing one’s attention beyond the here and now (e.g., through mind-wandering) for mood, memory, concentration, and comprehension (Mooneyham & Schooler, 2013) as well as work showing the positive benefits of focusing on the present (e.g., through mindfulness meditation) for mental health and physical well-being (Davidson et al., 2003; Keng, Smoski & Robins, 2011; Weinstein, Brown, & Ryan, 2009). Nonetheless, we show that because simulation enables people to generate a meaningful experience, it can also have benefits for one's sense of meaning. Given the links between meaning in life and a variety of positive outcomes, this research suggests that one way to improve psychological and physical well-being is to at least occasionally take a moment to distance oneself from the present time and place.

Meaning in Life as a Uniquely Human Experience

Daniel Gilbert (2009, pp. 3–4) playfully noted that all psychologists "take a vow, promising that at some point…they will publish a book, a chapter, or at least an article that contains this sentence: 'The human being is the only animal that…'" Gilbert then boldly completed the sentence by proclaiming,"The human being is the only animal that thinks about the future," qualifying that, "We think about the future in a way that no other animal can, does, or ever has." Although the capacity for mental time travel arguably exists in other animals (Corballis, 2012), as do other forms of simulation such as rudimentary abilities to employ theory of mind (Call & Tomasello, 2008), the most sophisticated forms of simulation seem to emerge exclusively in humans. Thus, given the results of the present work, we wish to fulfill the Psychologists'Vow by proposing that: The human being is the only animal that can experience meaning in life. Of course, we make this bold claim knowing that only future research can fully determine whether our assertion is correct. However, given our immense ability to transcend the here and now to mentally occupy alternate times, spaces, selves, and realities, it seems like a distinct possibility that the meaning we derive from transcendence is uniquely human.

Acknowledgments

The authors thank Adam Alter, Susanna Carmona, Brendan Gaesser, Adam Galinsky, Laura Kray, Fenna Krienen, Sarah Molouki and the laboratories of Jason Mitchell and Randy Buckner for support and assistance with this project. This work was supported by a National Research Service Award from the National Institutes of Health.

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Table 1

Measure	Correlation with MTL network	Correlation between MTL network and presence of meaning controlling for measure
Presence of Meaning	.25*	-
Search for Meaning	−.03	.26*
Altruism task	−.03	.26*
Satisfaction With Life	.17	.19+
Purpose in Life	.17	.19+
Emotion Focus (Rumination on Positive Affect; RPA)	.24*	.19
Dampening (RPA)	−.10	.24*
Self-Focus (RPA)	.16	.21+
Mania	.21+	.18
Author Recognition Test (ART)	−.09	.24*
Fiction (ART)	−.11	.23*
Non-Fiction (ART)	−.08	.25*
Autism Spectrum Quotient (ASQ)	−.15	.22+
Social Seeking (ASQ)	−.20+	.22+
Attention to Detail (ASQ)	.01	.25*
Attention Switching (ASQ)	−.09	.24*
Communication (ASQ)	−.16	.22+
Imagination (ASQ)	−.02	.25*
Interpersonal Reactivity Index (IRI)	−.05	.23*
Fantasy (IRI)	−.08	.23*
Empathic Concern (IRI)	.08	.24*
Perspective-Taking (IRI)	−.02	.24*
Personal Distress (IRI)	−.11	.23*
Personal Altruism Levels (PALS)	.09	.23*
Friend (PALS)	.04	.23*
Stranger (PALS)	.14	.23*
Depression	−.09	.24*

Note:

* $p<.05$,

\+ $p<.10$