Title:

The people around you are inside your head: Social context shapes spontaneous thought

Judith N. Mildner and Diana I. Tamir

Department of Psychology, Princeton University, Princeton, NJ 08544, USA

Author Note

Correspondence concerning this article should be addressed to Judith Mildner,
Department of Psychology, Princeton University, Peretsman-Scully Hall, Princeton, NJ 08544.
E-mail: jmildner@princeton.edu

Data and materials are available at <https://osf.io/cew8b/> and a preprint of this manuscript
has been posted on PsyArxiv: <https://psyarxiv.com/xmzh7/>.

Some of the ideas and data in this manuscript were presented as posters at the Annual
Convention of the Society for Personality and Social Psychology (2017), the New York Social
and Affective Neuroscience Meeting (2018), the Social and Affective Neuroscience Annual
meeting (2018), the APS Annual Convention (2018), and in a talk at a meeting of the European
Society for Social and Affective Neuroscience (2018).

Word count: 7821

Abstract

Humans are highly social. We spend most of our time interacting with the social world and we spend most of our thoughts thinking about the social world. Are we social beings by default, or is our sociality a response to the social world? On the one hand, fundamental social needs may drive social behavior. According to this account, social thoughts fulfill social needs when the environment is insufficiently social. On the other hand, spontaneous thoughts may process incoming information. According to this account, social thoughts reflect the social information in the environment. To arbitrate between these possibilities, we assessed the content of spontaneous thought during mind wandering in three social contexts: solitude (Study 1), social presence (Study 2), and social interaction (Study 3). Additionally, in Study 1, we used functional neuroimaging to measure neural activity while participants considered social and non-social targets. Results consistently showed that spontaneous thought reflects the sociality of the world around us: Solitude decreased spontaneous social thought and decreased neural activity in the mentalizing network when thinking about a close friend. Social presence did not change spontaneous social thought. Social interaction increased spontaneous social thought. Finally, individual differences analyses (Study 4) showed that people in more social environments have more social thoughts. Together, the results show a pattern of increasing social thought in increasingly social environments. The predominance of social content in spontaneous thought can thus be explained by the predominance of social content in the world around us, rather than our innate, fundamental social needs.

Keywords: spontaneous thought, mind wandering, social context, social cognition

The People Around You Are inside Your Head: Social Context Shapes Spontaneous Thought

The human mind is expansive; it is not limited by time, space, or even reality. We are capable of considering everything from the mundane to the fantastic. We can think about the sights and sounds that currently surround us, time travel into the past or far into the future. We can think about worms and wormholes, order and chaos, friends and fairies, and everything in between. With this vast landscape of thought at our minds' doorstep, what determines the content of our thoughts at any given time?

People overwhelmingly think about other people. In a large-scale survey on the content of people's thought, 73% of respondents reported that their daydreams were primarily about other people (Mar, Mason, & Litvack, 2012). In an experience sampling study, 70% of momentary thoughts were about people (Song & Wang, 2012). Neuroimaging research likewise suggests that our minds default to thinking about social content: The network of neural regions active at rest, the default network, becomes active when people engage in explicit social cognition (Buckner, Andrews-Hanna, & Schacter, 2008; Fox, Spreng, Ellamil, Andrews-Hanna, & Christoff, 2015; Schilbach et al., 2012; Spreng & Grady, 2009). Indeed, participants frequently think about other people during rest inside an MRI scanner (Diaz et al., 2013). Although spontaneous thought is multifaceted, social cognition is one of the clearest components of spontaneous thought (Andrews-Hanna, Smallwood, & Spreng, 2014). In other words, people's minds default to thinking about the social world (Lieberman, 2013; Meyer, in press).

This focus on social thought is perhaps unsurprising given that humans are embedded in a highly social world. People in the U.S. spend 45% of their waking lives in the presence of another person, and at least 20% directly interacting with others (U.S. Bureau of Labor Statistics, 2016). Every day, people exhibit countless social behaviors, large and small, in service of their

need for social connection. People choose social presence over social isolation, interact with others, groom their reputation and relationships, and serve others' needs (Baumeister & Leary, 1995; Chartrand & Bargh, 1999; Fantz, 1963; Jolly, Tamir, Burum, & Mitchell, 2019; Morelli, Lieberman, & Zaki, 2015). From simple preferences to complex and potentially costly actions, people's behaviors show a profound tendency toward the social.

When it comes to explaining the prevalence of social thought, the outsized presence of the social world raises a chicken and egg problem. Is our world social because our thoughts are inherently social, with both reflecting a fundamental need to connect with others (Baumeister & Leary, 1995; Lieberman, 2013)? Or are our thoughts social because our world is, with thoughts helping us to process our social environment?

A number of influential thinkers have argued that humans are inherently social, driven at all costs to connect with others (Baumeister & Leary, 1995; Lieberman, 2013). This account suggests that our thoughts may be social simply because we are inherently social beings. That is, people might think about the social world in order to help satiate our social needs. In this account, when the environment fails to provide people with sufficient social stimuli, the mind should fill that void by thinking about social content. There is evidence that our minds indeed work in this way: people who feel lonely attend more to social stimuli (Gardner, Pickett, Jefferis, & Knowles, 2005; Pickett, Gardner, & Knowles, 2004), and people with heightened social motivation ascribe more human characteristics to non-human entities (Epley, Waytz, & Cacioppo, 2007). These findings suggest that the less social content in the environment, the more people engage in social thought. Moreover, these social thoughts serve their purpose of fulfilling social needs. For example, in one experience sampling study, people reported increased feelings of connectedness and happiness after they daydreamed about a loved one, but only if they lacked

these positive social feelings before the daydream (Poerio, Totterdell, Emerson, & Miles, 2015). In another study, people completed a loneliness induction and then were randomly assigned to daydream about a close other, daydream about themselves, or complete a control task. People who daydreamed about a close other reported increased positive social feelings, love, and belonging (Poerio, Totterdell, Emerson, & Miles, 2016). Thus, the contents of thought can help regulate social needs. As such, the social environment may shape social thought because it determines the extent to which social needs are met. If spontaneous social thought reflects social needs, then the less social the environment, the more social spontaneous thought. We refer to this as the *social needs hypothesis*.

However, it is also possible that people become social thinkers because they live in a social world. That is, people's thoughts might gravitate toward the social simply because the world around them is so social. Social information may propagate throughout our thoughts as a spontaneous extension of responses to environmental cues (Northoff, 2018). Environmental cues activate not just associated thoughts (Bar, Aminoff, Mason, & Fenske, 2007), but also associated concerns or unfulfilled goals (Klinger, 1971, 2013). As such, the social environment might be an ongoing source of cues that activate current social concerns. This focus on the social environment in spontaneous thought may help to process incoming social information (Meyer, in press; Meyer, Davachi, Ochsner, & Lieberman, 2018) and prepare us to engage with the social world (Meyer, in press; Spunt, Meyer, & Lieberman, 2015). If spontaneous social thought reflects social information in the environment, then the more social the environment, the more social spontaneous thought. We refer to this as the *social processing hypothesis*.

The social needs and social processing hypotheses make divergent predictions about the relation between social environment and the content of thought. Here we arbitrate between these

hypotheses with three studies that assess thought content in environments that span a wide range of available social information: after a period of solitude (Study 1), during mere social presence (Study 2), and after social interaction (Study 3). In all three studies, we measured spontaneous thought content during mind wandering. Study 1 also assessed neural activity during social thought using fMRI. Additionally, we explored whether individual differences in social environment predict social thought (Study 4). These studies are presented in the order they were conducted. If the social needs hypothesis is true, social content should decrease with increasingly social environments, as the need for sociality is fulfilled. If the social processing hypothesis is true, social thought content should increase in more social environments, as the amount of external social information increases.

Study 1: Solitude

In this study, participants encounter no social information for an extended period of time -- a seven-hour period of solitude. This allows us to measure the impact of a minimally social environment on the content of social thought, measured both behaviorally and neurally.

Methods

Data and code have been deposited on the Open Science Framework (<https://osf.io/cew8b/>) and are freely available. We report how we determined sample size, all data exclusions, all manipulations, and all measures in the study.

Participants

A total sample size of 80 participants, 40 per condition, was set a priori based on data from a pilot study that employed a similar solitude manipulation. Data collection stopped once that target was reached for all conditions. In the pilot data, this sample size allowed for 80% power to detect the expected effect of interest within a neural region of interest. Participants were

recruited from Princeton University's paid subject pool, which consists mostly of students, but also includes some staff and community members. To balance conditions, we scheduled control and experimental participants on the same day where possible. We collected data until we reached a sample size of 80 in the fMRI portion of the study, with participants tallied at the end of each day. We recruited a total of 87 participants (age $M = 19.9$, $SD = 1.9$, range = 18-28; 58.6% female; 36.8% White/European American, 17.2% Black/African American, 16.1% bi-racial or multi-racial, 12.6% East Asian/East Asian American, 8.0% South Asian/South Asian American, 6.9% Latino/Hispanic American) who were right handed, met the safety criteria for MRI scanning, and reported no history of anxiety or depression and no psychoactive medication. Six participants were unable to complete the scanning session due to technical difficulties ($n = 3$) or peripheral nerve stimulation ($n = 3$), leaving a total of 81 participants in the fMRI portion of this study, 39 in the solitude condition, and 42 in the control condition.

All participants who complied with task instructions on the mind wandering task were included in the behavioral analyses. Participants were excluded based on the following a priori criteria, used in this and all subsequent studies: leaving more than 20% of responses blank (solitude $n = 2$, control $n = 1$), taking longer than 15 seconds to respond to a prompt more than twice over the course of the experiment ($n = 0$), reporting no mind wandering (i.e. paying attention to the reading) while moving through the text too quickly to read (solitude $n = 3$, control $n = 2$). The latter was operationalized as spending less than 1 second on the two pages preceding a probe, then answering "no" when asked if they were mind wandering. After exclusions, the sample size for the behavioral analyses was 79, 36 in the solitude condition, and 43 in the control condition.

Informed consent was obtained from all participants in accordance with the Princeton University Institutional Review Board.

Experimental manipulation

Participants were randomly assigned to one of two conditions: solitude or control. On the day of the experiment, all participants first provided informed written consent. Participants then completed a mock MRI scanning session to ensure they were familiar and comfortable with the MRI scanning procedure. Participants in the control condition left the lab after the mock MRI session to go about their day as normal. They came back to the lab seven hours later to complete the remainder of the experiment. Participants in the solitude condition spent the next seven hours alone in a room. The room contained no reference to people or social stimuli. The room contained only puzzles, Sudoku, drawing supplies, a coloring book, a mini basketball set, and a laptop with no internet access. The laptop had non-social games, books, nature videos, and basic word processing software. Participants had no access to any other electronic devices. Snacks, water, and a lunch of the participant's choosing were provided. Participants were allowed to bring their own drawing, coloring, writing, or studying supplies. All materials in the room, including items participants brought, were screened to ensure they contained no social stimuli. Participants were instructed to put in a pair of earplugs whenever they went to the restroom, to limit their exposure to conversations in the hallway.

To ensure participants' comfort and safety, the laptop had a custom applet installed that participants could use to contact the researcher or stop the experiment. Participants were told they could use it any time they had an urgent question or wanted to stop the study for any reason. When a participant used the applet, an alarm would go off on the experimenter's computer and the experimenter could see the participant's message and respond by sending a notification to the

participant's laptop. This applet was used by 5 participants to request a fork, napkins, or feminine hygiene products or to report technical difficulties during a task.

Participants in the control condition reported on their social behaviors every hour. These participants engaged in more social interaction, as expected: They spent, on average, 102 ($SD = 94$) minutes interacting with other people face-to-face, and 86 ($SD = 82$) minutes around other people but not interacting with them. On average, they also sent 20 ($SD = 24$) text or instant messages, checked social media 8 ($SD = 7$) times, and sent 2 ($SD = 3$) emails.

Experience sampling

Participants completed 7 short surveys throughout the day, one at the start of the experiment (hour 0), and one at the end of every hour for the subsequent 6 hours. In the solitude condition, participants received a notification on the laptop each hour with a link to the survey. In the control condition, participants received an email with a link to the survey and could opt in to text message reminders, as well (See SI for full list of items). The experience sampling data were not analyzed as part of this paper.

Mind wandering

After seven hours, participants completed a mind wandering task in the lab. In this task, modelled off earlier work (McVay & Kane, 2012; Reichle, Reineberg, & Schooler, 2010), participants read a text on the computer for a total duration of 40 minutes. The text was "Successful beekeeping A-B-C's" by Terry Martyn Jr., a text selected to be relatively boring, and to have minimal social content. Participants read the text at their own pace. Every two to four minutes, participants' reading was interrupted with a 2-item probe measuring whether or not their mind was wandering, and what they were thinking about. First, they responded "yes" or "no" to the question: "Just prior to being asked, were you mind wandering?" Next, they provided

an open-ended text response to the question: “What were you thinking about?” After answering these questions, participants resumed reading the text. Each participant responded to an average of 10.98 ($SD = 2.57$) thought probes.

Responses to the first question of each probe served as a measure of self-reported mind wandering. Responses to the second question served as a measure of the content of participants’ spontaneous thought. We quantified the social content of these thoughts using both an objective and a subjective measure. We used the same two measures in all studies. The objective measure used Linguistic Inquiry and Word Count software (LIWC2015) (Pennebaker, 2015). LIWC counts the proportion of words in a text that fall into various psychologically relevant categories; we measured the proportion of words in each thought that fall into LIWC’s “social” category, which includes words like family, friend, talk, and dance. The subjective measure of social thought was obtained using independent raters on Amazon’s Mechanical Turk (mTurk). Each thought was rated by 10 mTurk raters on a scale of 1-100 to indicate how social the thought was. Specifically, raters were told to focus on mentalizing with the following instructions: “On each trial, you will rate a statement on how much it is about: reflecting on someone else’s thoughts, feelings, preferences, intentions, or personality. You will rate the extent to which the statement pertains to the thoughts and feelings of other people.” Raters were excluded if they had a standard deviation of 10 points or less in their ratings (see SI for more details). Inter-rater reliability was measured using intra-class correlation (ICC). The average rating of social content served as the subjective measure of social thought. The same raters also provided ratings of task-related content, memory-based simulation, introspection, and semantic information (See SI for results on these ratings).

To measure the effect of solitude on the content of spontaneous thought, we analyzed the objective and subjective measures of social thought using a mixed-effects model for each of these variables. These models contained fixed effects for self-reported mind wandering (yes or no) and condition (solitude or control). Since each participant contributed multiple trials, the model also contained a random intercept for each participant. We did not include random slopes, to ensure model convergence.

fMRI scanning

After the mind wandering task, participants completed an fMRI scanning session. To ensure minimal social interaction for participants in the solitude condition, these participants received a notification on the computer with instructions to prepare for scanning and put in earplugs. They were then escorted to the scanner with minimal verbal instruction and eye contact. Since participants had completed mock scanning at the start of the day and they received written instructions immediately before scanning, the experimenter was able to scan participants safely and comfortably while speaking only 1-3 sentences throughout the scanning session.

Procedure. Scanning was conducted at the Princeton Neuroscience Institute with a 3 Tesla Siemens Prisma MRI scanner and 20-channel head coil. Functional scans were acquired with a T2*-weighted simultaneous multi-slice (SMS) echo-planar pulse sequence with 62 interleaved slices (TR/TE = 2250/32ms, flip angle = 70°, 128 x 64 matrix, 2.0 mm thick, field of view (FOV) = 192mm, SMS factor = 2). Participants completed 4 runs of 133 TRs each. Additionally, 6 volumes of spin echo images were acquired, with opposite phase encoding directions. These were used to calculate fieldmaps for the functional scans using FSL's Topup tool (Andersson, Skare, & Ashburner, 2003). Finally, a proton density weighted structural volume was acquired (TR/TE = 8400/11ms, flip angle = 160 °, 256 x 256 matrix, 1.5 mm thick,

FOV = 218mm). The functional data were preprocessed using SPM12 (Wellcome Trust Centre for Neuroimaging) for motion correction and unwarping based on the fieldmap, and using the DARTEL toolbox (Ashburner, 2007) for coregistration of functional and structural volumes, normalization to MNI space, and smoothing with a 6mm FWHM kernel. Finally, low frequency noise was removed with a high pass filter (128 seconds).

Task. During scanning, participants completed a social inferences task (Tamir & Mitchell, 2012). In this task, participants judged the preferences of three targets: self, a close friend, or an unfamiliar other (i.e., Barack Obama). On each trial, participants first saw a cue that indicated the target of the judgment (e.g., self, friend's name, or Obama) for 1.5 seconds, followed by a brief statement (e.g., "enjoy browsing a book store for an hour"). Participants then had 3 seconds to rate how likely the statement was to apply to the target on a scale from 1-5, anchored on very unlikely to very likely. Participants indicated their ratings using a button box with five buttons, held in their right hand. Each statement was rated once for the self, and once for either the close friend or the unfamiliar other. The task also included non-social control trials, where participants judged how likely an activity was to occur indoors. On these trials, participants saw the target (i.e., indoors) and a statement describing an activity for the same duration as in all other trials, and made their response using the same button box and scale. Trials were presented in randomized order, with variable fixation periods between trials. Order of trials and duration of fixation periods was optimized using Optseq2 (Dale, 1999).

During the scanning session, participants also completed a control attention task, and a task in which they shared, or privately answered questions about themselves (see SI for detailed description). All participants completed the attention task first, followed by the social inferences

and sharing tasks in counterbalanced order. They then also completed a 7-minute resting state scan. These tasks and the resting state scan were not analyzed as part of this paper.

Analysis. Preprocessed fMRI data for each participant were modeled using a general linear model. The model included regressors for target (self, friend, unfamiliar other, indoors) and their temporal derivatives, as well as nuisance regressors for each of the 6 motion parameters calculated during motion correction.

To measure social thought during the social inferences task, we examined neural responses specifically within brain regions associated with social thought. To independently localize brain regions associated with social thought, we used Neurosynth (neurosynth.org), an automated meta-analysis tool, to identify regions of the brain that are associated with the terms “mentalizing” or “social cognit*”. The resulting statistical map was thresholded at a false discovery rate of 0.01. From this map, all clusters with an extent of at least 20 voxels and values in the 75th percentile or higher were extracted to form a mentalizing network ROI. This network (Figure 2a) included ventromedial prefrontal cortex (vmPFC), dorsomedial prefrontal cortex (dmPFC), posterior cingulate cortex (PCC), bilateral temporal parietal junction (TPJ), temporal pole (TP), and a portion of superior temporal sulcus (STS).

Results

Mind wandering

If it is the case that social context affects the content of spontaneous thought, we expected to find an interaction effect between self-reported mind wandering and condition, such that participants in the solitude condition show either increased or decreased spontaneous social thoughts, relative to control participants, specifically when they report they are mind wandering. This study did not have a priori hypotheses about the direction of the effect, nor about the

specificity of the effect on social thought (vs. introspection and simulation). As such, the results here were used to arbitrate between two possible hypotheses: if solitude participants show greater social thoughts, this would provide evidence in favor of the social needs hypothesis; if solitude participants show fewer social thoughts, this would provide evidence in favor of the social processing hypothesis.

In line with the social processing hypothesis, participants in the solitude condition had fewer social thoughts during mind wandering than participants in the control condition, according to the subjective measure (Mind wandering $M_{control} = 13.47$, $SD_{control} = 15.12$, $M_{solitude} = 9.65$, $SD_{solitude} = 11.66$; No mind wandering $M_{control} = 12.55$, $SD_{control} = 11.29$, $M_{solitude} = 13.19$, $SD_{solitude} = 12.20$). That is, there was a significant negative interaction effect between mind wandering and condition ($\beta = -4.62$, $SE = 1.91$, $p = 0.02$). The objective measure of social thought showed a non-significant interaction between mind wandering and condition in the same direction ($\beta = -1.74$, $SE = 1.02$, $p = 0.09$; Mind wandering $M_{control} = 4.90$, $SD_{control} = 6.74$, $M_{solitude} = 3.78$, $SD_{solitude} = 6.28$; No mind wandering $M_{control} = 6.95$, $SD_{control} = 7.41$, $M_{solitude} = 7.57$, $SD_{solitude} = 7.30$). These results are in line with the social processing hypothesis: spontaneous social thought decreases after a period of solitude (Figure 1).

Figure 1. In line with the social processing hypothesis, spontaneous social thought increases in increasingly social environments. Relative to control conditions, social thought during mind wandering decreases after a period of solitude (Study 1), remains unchanged during social presence (Study 2), and increases after social interaction (Study 3). Error bars reflect bootstrapped 95% confidence intervals.

fMRI

To measure the effect of solitude on deliberate social thought, we examined neural activation in the mentalizing network while participants made social inferences. The magnitude of the activity in this network in response to each of the three targets – self, friend, Obama – served as a neural measure of social thought. If the social processing hypothesis is supported, there would be less activation in the mentalizing network in response to social targets for participants in the solitude condition, relative to controls. If the social needs hypothesis is supported, the opposite pattern should emerge. We expect no difference between conditions in response to the control target. Again, this study had no a priori hypotheses about the direction of this effect, or about its specificity to social targets rather than the self.

The neuroimaging findings converged with the results from the mind wandering task and supported the social processing hypothesis (Figure 2). When making inferences about the preferences of a close friend, participants in the solitude condition had less activity in the mentalizing network than controls ($M_{solitude} = 1.072$, $M_{control} = 1.407$, $t(72.236) = 2.09$, $p = 0.040$). This effect was specific to the friend condition, as there were no significant group differences in this network for the self, Obama, or indoor conditions.

Together, these findings provide preliminary evidence that the social environment shapes social thought. In particular, we find that after a period of solitude, social thought decreased. The behavioral results show this effect in spontaneous thought during mind wandering, and the neural results show a similar pattern for task-related social thought about a close friend.

Figure 2. Within the mentalizing network (a), activity while thinking about a close other decreases after a period of solitude. This network shows no differences between conditions for other targets (b). Error bars reflect bootstrapped 95% confidence intervals.

Study 2: Social presence

If the social processing hypothesis is true and spontaneous social thought reflects the social environment, social thought should increase in more social environments. Study 2 measured social thought in a slightly more social environment: during mere social presence.

Methods

Participants

Target sample size was determined using a simulation-based power analysis based on the mixed model for the subjective measure of social content in Study 1. We used the *simr* package (Green & MacLeod, 2016) to add simulated data based on the observed parameters in this model. With 80 participants the simulated dataset had 878 total data points, and an estimated 83.9% power (95% confidence interval: 81.47 – 86.13); with 95 participants and 1000 total data points, the simulated dataset had 87.5% power to detect the interaction effect observed in Study 1. We increased the sampling rate of the paradigm in Study 2 to collect 1000 total data points from 80 participants, and as such, we set a target sample size of 80 participants.

We stopped data collection once the target sample size was reached. Since participants came in in groups that were scheduled in advance, we tallied participants at the end of each study day. We recruited 91 participants from Princeton University's psychology subject pools (age $M = 20.3$, $SD = 3.1$, range = 18-35; 62.2% female; 47.7% White/European American, 23.3% East Asian/East Asian American, 13.3% bi-racial or multi-racial, 5.6% Black/African American, 4.4% Latino/Hispanic American, 2.2% South Asian/South Asian American, 1.1% Middle Eastern/Arab American). Six participants were excluded for not complying with mind wandering task instructions, using the same exclusion criteria as in Study 1, leaving a sample size of 85 participants, 42 in the social presence condition, and 43 in the control condition. One participant

is included who had also completed Study 1. Excluding this participant did not change the results of the study.

Experimental Manipulation

Participants were assigned to either the social presence condition or the control condition. As in Study 1, participants in the control condition completed the task while seated in a room by themselves. The social presence condition was designed to have multiple people together, but not interacting. This condition mimicked mere presence manipulations in various previous studies (Markus, 1978; Schmitt, Gilovich, Goore, & Joseph, 1986; Zajonc, 1965). Participants in the social presence condition completed the task while seated next to one or two other participants. Participants did not get a chance to interact before the task and all participants in this condition reported they did not know each other prior to the experiment. This ensured that mere presence was the only factor that differed between the two conditions.

Mind Wandering

Participants in all conditions completed the same mind wandering task from Study 1. To obtain more responses per participant, the task duration was extended to 45 minutes. To avoid having to exclude participants who completed the first study, we chose a different text. The text participants read in this version of the task was “A-B-C of vegetable gardening” by Eben E. Rexford (retrieved from <https://www.gutenberg.org>). This text contained minimal social content. Each participant responded to an average of 12.4 (SD = 1.3) thought probes.

Results

Based on the results from Study 1, we expected to find further evidence for the social processing hypothesis: there should be a positive interaction effect of mind wandering and condition on the subjective and objective measures of social thought. In other words, participants

in the social presence condition should show increased spontaneous social thought relative to controls.

Results did not support this hypothesis. Mere social presence did not change the content of thought compared to completing the task in the control condition. There were no significant interaction effects for self-reported mind wandering and condition on either the objective measure of social thought ($\beta = 0.44$, $SE = 0.46$, $p = 0.54$; Mind wandering $M_{control} = 3.51$, $SD_{control} = 4.94$, $M_{social\ presence} = 3.68$, $SD_{social\ presence} = 5.50$; No mind wandering $M_{control} = 3.55$, $SD_{control} = 4.55$, $M_{social\ presence} = 3.34$, $SD_{social\ presence} = 4.47$), or the subjective measure ($\beta = 0.50$, $SE = 2.42$, $p = 0.84$; Mind wandering $M_{control} = 18.27$, $SD_{control} = 18.87$, $M_{social\ presence} = 20.74$, $SD_{social\ presence} = 21.23$; No mind wandering $M_{control} = 17.3$, $SD_{control} = 16.33$, $M_{social\ presence} = 19.27$, $SD_{social\ presence} = 17.26$). These results indicate that mere social presence does not affect the social content of spontaneous thought. That said, mere social presence during a relatively short task (45 minutes) may not have added sufficient social information into the environment to alter participants' social thought. In fact, to be truly comparable to Study 1, participants in this study would have had to be exposed to 7 hours of mere social presence.

Study 3: Social interaction

Study 2 showed that mere social presence was not sufficient to increase spontaneous social thought, relative to being alone. It is possible that social processing prepares us to engage with others and for that reason only increases spontaneous social thought when the environment supports social interaction, rather than passive social presence. Alternatively, the mere social presence condition in Study 2 may be similar to the typical social environment experienced by our participants. As such, the difference in social environment between the control group and mere presence group may have been too subtle to detect any difference. Study 3 used a stronger

manipulation of social context than Study 2, in an attempt to fully reverse the effect observed in Study 1. We preregistered the hypothesis that introducing new social information to the environment, by having participants interact with each other, should increase spontaneous social thought (<https://osf.io/hjfuq>).

Methods

Participants

Sample size and stopping criteria were determined in the same way as in Study 2. This study was preregistered with a sample size of 80 participants (40 per condition). We recruited 87 participants from Princeton University's psychology credit pool (age $M = 19.4$, $SD = 2.0$, range = 18-29; 64.4% female; 40.2% White/European American, 17.2% East Asian/East Asian American, 13.8% bi-racial or multi-racial, 8.0% Black/African American, 8.0% Latino/Hispanic American, 8.0% South Asian/South Asian American, 1.1% Middle Eastern/Arab American). Two participants were excluded because they already knew each other prior to the manipulation. Three participants were excluded based on the same criteria from Studies 1 and 2, leaving a final sample of 82 participants, 40 in the social interaction condition and 42 in the control condition. One participant is included who had also completed Study 1. Excluding this participant did not change the results of the study.

Experimental Manipulation

Participants were assigned to one of two conditions: social interaction or control. The control condition was the same as in Studies 1 and 2: participants did the mind wandering task while they were alone, after going about their day as normal. In the social interaction condition, two participants came to the lab at the same time. They first completed the Fast Friends Procedure (Aron, Melinat, Aron, Vallone, & Bator, 1997). In this procedure, the pair of

participants gets index cards with questions on them. They take turns reading and answering each question out loud. The questions are designed to elicit interpersonal closeness between two strangers. As the participants go through the stacks of cards, the questions become increasingly personal in nature. After 30 minutes, the Fast Friends Procedure ended, and participants began the mind wandering task as described in Study 1, while sitting side-by-side.

Mind Wandering

Participants in both conditions completed the same mind wandering task from Study 2, with text from “Animals of the past” by Frederic A. Lucas (retrieved from <https://www.gutenberg.org>). Each participant responded to an average of 11.8 (SD = 1.4) thought probes.

Results

We used the same analysis strategy described in Study 1 to measure the effect of social interaction on subsequent spontaneous thought content. Analyses tested the preregistered hypothesis that social interaction should increase social thought. That is, in contrast to the results from Study 1, which showed that isolated participants had less social thought during mind wandering (a negative interaction between self-reported mind wandering and condition), here we expected to see that social interaction participants have more social thought during mind wandering (a positive interaction between mind wandering and condition).

As predicted, social thought during mind wandering increased for participants in the social interaction condition relative to controls. There were significant interaction effects between mind wandering and condition on both the subjective measure of social thought ($\beta = 5.51$, $SE = 2.02$, $p = 0.007$; Mind wandering $M_{control} = 16.26$, $SD_{control} = 14.11$, $M_{social\ interaction} = 21.47$, $SD_{social\ interaction} = 22.03$; No mind wandering $M_{control} = 14.49$, $SD_{control} = 11.8$, M_{social}

$interaction = 14.22$, $SD_{social\ interaction} = 12.79$), as well as the objective measure ($\beta = 2.66$, $SE = 0.76$, $p < 0.001$; Mind wandering $M_{control} = 3.83$, $SD_{control} = 5.11$, $M_{social\ interaction} = 6.44$, $SD_{social\ interaction} = 8.02$; No mind wandering $M_{control} = 3.46$, $SD_{control} = 4.75$, $M_{social\ interaction} = 3.54$, $SD_{social\ interaction} = 4.86$), such that participants in the social interaction condition had more social thought during mind wandering.

Taken together, the three studies show a pattern of increasing spontaneous social thought in increasingly social environments (Figure 1), where, compared to a control condition, solitude decreases social thought (Study 1), mere presence does not affect social thought (Study 2), and social interaction increases social thought (Study 3).

Study 4: Individual differences in social needs

Studies 1-3 find consistent support for the social processing hypothesis. However, it is still possible that social needs shape social thought independently of the quantity of social content in the environment. In Study 4, we conducted exploratory analyses that capitalize on the natural variance in participant's social environments. All participants in the control condition in Studies 1-3 ($N = 128$) completed the mind wandering task in the same social environment. However, they arrived at the experiment after experiencing very different social lives. We assessed the richness of their ongoing social world with measures of loneliness (Russell, 1996), need to belong (Leary, Kelly, Cottrell, & Schreindorfer, 2013), and tendency and efficacy in seeking out interpersonal regulation (IRQ; Williams, Morelli, Ong, & Zaki, 2018) after the mind wandering task. According to the social needs hypothesis, high scores on all of these measures should predict more social thought; lonely individuals have unfulfilled social needs, and individuals with high need to belong and IRQ likely have high social needs by default. In contrast, according to the social processing hypothesis, high scores on need to belong and IRQ,

but low scores on loneliness should predict more social thought; individuals with high need to belong and IRQ likely seek out social environments regularly, whereas lonely individuals likely inhabit less social environments. Thus, we used these individual difference measures to test these competing predictions, focusing on loneliness in particular as the measure that offers the only distinction between these two hypotheses.

Methods

Participants

All control group participants used in the first three studies were also used in this study. This made for a total sample size of 128 participants.

Measures

The content of spontaneous thought was measured both objectively and subjectively, as in Studies 1-3. Social needs were measured using the UCLA Loneliness Scale (Russell, 1996), the Need to Belong Scale (NTB) (Leary et al., 2013), and the Interpersonal Regulation Questionnaire (IRQ) (Williams et al., 2018).

The UCLA Loneliness Scale (Russell, 1996) measures loneliness in 20 items such as “How often do you feel left out?” and “How often do you feel part of a group of friends?” that participants respond to using a four-point scale of never, rarely, sometimes, or always. After reverse coding positively worded items, all responses are summed to yield a loneliness score with a maximum of 80.

The need to belong scale (Leary et al., 2013) is a 10-item questionnaire that includes items like “I want other people to accept me” and “I do not like being alone.” Participants respond to these items using a 5-point likert scale of “Strongly disagree” to “Strongly agree”. Responses are summed to yield a need to belong score with a maximum of 50.

The IRQ (Williams et al., 2018) measures interpersonal emotion regulation strategies in terms of tendency to seek out other people for emotion regulation and efficacy of seeking out others for emotion regulation. Tendency and efficacy are measured for both positive and negative emotions. Therefore, there are 4 subscales: tendency-positive, tendency-negative, efficacy-positive, and efficacy-negative. Each subscale is measured in 4 items, for a total of 16 items. For each subscale, responses are averaged to yield a score with a maximum of 7. The average of all items serves as an overall score.

For each of the survey scales, we fit linear models with social thought as the outcome variable and self-reported mind wandering, the survey score, and their interaction as predictors. To account for multiple observations of thought content per participant and the nesting of participants in different studies, the model also included random intercepts for each participant, and for study. As such, there were 2 models per survey measure: one for the objective and subjective measure of social thought, respectively.

The questionnaires described above are the only questionnaires related to social needs administered in these studies.

Results

Analyses of the main effect of objective measure of social thought supported the social processing account: the more an individual spontaneously thought about social content, the lower their loneliness ($\beta = -0.066$, $SE = 0.027$, $p = 0.014$). The subjective measure of social thought showed no relation with loneliness ($\beta = -0.019$, $SE = 0.084$, $p = 0.82$). Need to belong and IRQ scores did not correlate with objective social thought (need to belong: $\beta = 0.056$, $SE = 0.034$, $p = 0.10$; IRQ: $\beta = 0.003$, $SE = 0.214$, $p = 0.98$) or subjective social thought (need to belong: $\beta = 0.183$, $SE = 0.106$, $p = 0.09$; IRQ: $\beta = 0.930$, $SE = 0.681$, $p = 0.27$). There were no significant

interactions between self-reported mind wandering and survey scores, for any measure, suggesting that social thought was similarly impacted during both spontaneous mind wandering thoughts and non-mind wandering thoughts.

Since higher loneliness was correlated with fewer social thoughts, these results provide tentative support for the social processing account, and against the social needs account, although this does not appear to be specific to *spontaneous* social thought.

General Discussion

Spontaneous thoughts predominantly feature other people. Here, we examined why people's thoughts gravitate toward the social world. Are we social beings by default, driven to think social thoughts and seek out social environments by a fundamental need for social connection? Or do our social thoughts reflect our constant exposure to the social world around us? The current studies help to arbitrate between two respective hypotheses about how the social environment impacts social thought: social processing and social needs. Across three studies, we found consistent evidence for the social processing hypothesis: spontaneous social thought matches the social content available in the environment. Spontaneous social thought decreased after a period of solitude (Study 1), remained stable during mere social presence (Study 2), and increased after social interaction (Study 3). These findings consistently show that increasingly social environments produce increasingly social thought. This pattern of results suggests that people may think about the social world because they are so embedded in it, not because they need to.

This interpretation of the data is subject to some important caveats. First, the effect size in any individual study is small. Second, we are operationalizing social thought in two ways, using an objective and a subjective measure, which could inflate the false positive rate. Third, the

effect of social isolation on social thought in Study 1 was only statistically significant in the subjective measure of social thought, but not the objective measure. That said, the effect of social interaction on social thought in Study 3 was statistically significant in both the subjective and objective measure of social thought. Moreover, the pattern of results is consistent across with the social processing account all three studies, including across both behavioral and neural measures. As such, we interpret the results as evidence for the social processing hypothesis.

The social environment likewise shaped task-related social thought. After a period of solitude, neural activation in brain regions associated with social thought decreased. This effect was specific to social thought about a socially relevant target, a close friend. Solitude did not alter neural activity while considering an unfamiliar other, the self, or a non-social target. People rely on more specific information when making inferences about a close other, and on more generic social knowledge when making inferences about a more distal other (Ames, 2004; Tamir & Mitchell, 2013; Zhao et al., in press). This process is associated with activity in MPFC, a core hub in the mentalizing network, which responds more strongly to close others than strangers (Krienen et al., 2010; Welborn & Lieberman, 2014). Therefore, social isolation may specifically decrease this deep, person-specific processing of social information. Future research should test how social context influences thought about more nuanced categories of social content, including content ranging in social relevance, as well as additional types of spontaneous and task-directed social thought, like theory of mind, perspective taking, and empathy.

Exploratory analyses suggested that individuals who tend to experience less social interaction in their daily life also have fewer spontaneous social thoughts. Participants with insufficient meaningful social interaction showed less social thought. This finding contrasts with previous work showing increased sensitivity to social stimuli with increased loneliness (Gardner

et al., 2005). However, this finding is consistent with the social processing account to the extent that loneliness reflects less social environments. To be sure of the implications of this finding for the social processing account, future work should assess the relation between these individual difference measures and experienced – rather than inferred – social interaction. Further, it is possible that these individual difference measures are insufficient to test the social needs account. Future work should directly manipulate social needs to provide a full test of the social needs hypothesis.

Here, we found consistent evidence that spontaneous social thought reflects the social environment. This finding raises the possibility that spontaneous thought helps people to process new information in the social world. Such spontaneous processing can serve an important function: Processing new information during rest can boost memory for this information (Ellenbogen, Hu, Payne, Titone, & Walker, 2007; Tambini, Ketz, & Davachi, 2010). In a recent neuroimaging study, brain regions associated with social thought showed increased coupling during periods of rest that followed a social task. Moreover, this neural coupling predicted performance on a subsequent memory test (Meyer et al., 2018). Social information from the external world propagated into spontaneous social processing during rest, and this social processing benefited retention of the new social information. Thus, it is likely that spontaneous social thought serves an adaptive purpose: It helps people integrate new social information to support later social cognition (Meyer, in press). Future work should examine potential benefits of spontaneous social thought for social functioning.

These findings contextualize the claim that humans are social by default (Lieberman, 2013; Meyer, in press; Schilbach, Eickhoff, Rotarska-Jagiela, Fink, & Vogeley, 2008). We may spend a majority of our time thinking about the social world (Mar et al., 2012), devote our

default neural activity to social tasks (Diaz et al., 2013; Meyer et al., 2018; Schilbach et al., 2008), and make social and prosocial decisions by default (Baumeister & Leary, 1995; Chartrand & Bargh, 1999; Jolly et al., 2019). However, these defaults seem to be a *response* to the sociality of the world around us, rather than the *source* of our world's sociality. That is, people may be so doggedly social because we have learned that it is necessary to attend to the social world; this sociality may then persist because people are adept at learning the necessary social skills early in development (Atzil, Gao, Fradkin, & Barrett, 2018). If a person lives a day, or a life, with the din of the social world on mute, their mind will then no longer gravitate toward the social (Senju, 2013). We look forward to future work that further teases apart the extent to which our social drives are innate or just overlearned (Tamir & Hughes, 2018), perhaps by studying natural experiments in social isolation, with periods of isolation earlier in development, or longer than those studied here. The social distancing policies enforced to combat the Covid-19 pandemic may offer one such natural experiment.

Because the social world is such a profound factor in shaping much of human life (Baumeister & Leary, 1995; Fiske, Gilbert, & Lindzey, 2010), sociality provides an ideal case for testing the role of the environment in shaping thought. However, we do not expect *only* social experiences to be reflected in spontaneous thought. Instead, spontaneous thought often reflects one's salient, important, or recent experiences, social or not. Indeed, research has shown that people (and animals) spontaneously replay recent experiences from their episodic memory during periods of quiet rest (Ellenbogen et al., 2007; Tambini et al., 2010). This memory replay is essential for optimal memory consolidation (Fachechi, Agliari, & Barra, 2019; Wamsley, 2019). Thus, the effects here are likely not limited to social information alone; non-social environmental factors or experiences should similarly shape spontaneous thought.

When people's minds wander, their thoughts overwhelmingly gravitate towards the social world. As Michael Gazzaniga (2008) put it: "When you get up in the morning, you do not think about triangles and squares... You think about status. You think about where you are in relation to your peers. You're thinking about your spouse, about your kids, about your boss. Ninety-nine percent of your time is spent thinking about other people's thoughts about you, their intentions..." While Gazzaniga may have overestimated the extent of our spontaneous social thought, he was right that other people occupy the preponderance of our mental life. Here we shed light on the source of that preoccupation. Simply, the external social world is reflected in internal thoughts: The more social information in the environment, the more social our thoughts.

Context of the Research

Social psychologists often assume that people are innately, or invariably social. Indeed, humans are highly social; people thrive when they have social connections, and falter when they are deprived of social connections. However, we propose that people may not be social *by default*, but rather, as a response to the sociality of their environment. With this research we set out to examine how the social world shapes the content of our spontaneous thought. Our findings suggest that people think about the social world because the world contains a lot of social stimuli to process – evidence in favor of a social processing hypothesis; our findings do not support the hypothesis that people think about the social world in order to fulfill insatiable social needs. In future work, we plan to extend these findings to real-world changes in social environments. Our experiments induced only short-term changes in people's social environments. In the real world, people can experience prolonged and disruptive changes to their social world. The COVID-19 pandemic has created an unprecedented upheaval of people's social environments; this natural experiment in social distancing allows us to measure the impact of the social environment on

thought samples collected throughout the pandemic. Through this project and others we aim to further our understanding of the relationship between the environment and spontaneous thought.

References

- Allport, G. W., & Ross, J. M. (1967). Personal religious orientation and prejudice. *Journal of Personality and Social Psychology*, 5(4), 432.
- Ames, D. R. (2004). Inside the mind reader's tool kit: Projection and stereotyping in mental state inference. *Journal of Personality and Social Psychology*, 87(3), 340–353.
<https://doi.org/10.1037/0022-3514.87.3.340>
- Andersson, J., Skare, S., & Ashburner, J. (2003). How to correct susceptibility distortions in spin-echo echo-planar images: application to diffusion tensor imaging. *Neuroimage*, 20(2), 870–888. [https://doi.org/10.1016/S1053-8119\(03\)00336-7](https://doi.org/10.1016/S1053-8119(03)00336-7)
- Andrews-Hanna, J. R., Smallwood, J., & Spreng, R. N. (2014). The default network and self-generated thought: Component processes, dynamic control, and clinical relevance. *Annals of the New York Academy of Sciences*, 1316(1), 29–52.
<https://doi.org/10.1111/nyas.12360>
- Aron, A., Aron, E. N., & Smollan, D. (1992). Inclusion of other in the self scale and the structure of interpersonal closeness. *Journal of Personality and Social Psychology*, 63(4), 596.
- Aron, A., Melinat, E., Aron, E. N., Vallone, R., & Bator, R. J. (1997). The Experimental Generation of Interpersonal Closeness: A Procedure and Some Preliminary Findings. *Personality and Social Psychology Bulletin*, 23(4), 363–377.
<https://doi.org/10.1177/0146167297234003>
- Ashburner, J. (2007). A fast diffeomorphic image registration algorithm. *NeuroImage*, 38(1), 95–113.
- Atzil, S., Gao, W., Fradkin, I., & Barrett, L. F. (2018). Growing a social brain. *Nature Human Behaviour*, 2(9), 624. <https://doi.org/10.1038/s41562-018-0384-6>

- Bar, M., Aminoff, E., Mason, M., & Fenske, M. (2007). The units of thought. *Hippocampus*, 17(6), 420–428. <https://doi.org/10.1002/hipo.20287>
- Baron-Cohen, S., & Wheelwright, S. (2004). The empathy quotient: An investigation of adults with Asperger syndrome or high functioning autism, and normal sex differences. *Journal of Autism and Developmental Disorders*, 34(2), 163–175.
- Baumeister, R. F., & Leary, M. R. (1995). The need to belong: desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin*, 117(3), 497–529. <https://doi.org/10.1037/0033-2909.117.3.497>
- Buckner, R. L., Andrews-Hanna, J. R., & Schacter, D. L. (2008). The Brain's Default Network. *Annals of the New York Academy of Sciences*, 1124(1), 1–38. <https://doi.org/10.1196/annals.1440.011>
- Chartrand, T. L., & Bargh, J. A. (1999). The chameleon effect: The perception–behavior link and social interaction. *Journal of Personality and Social Psychology*, 76(6), 893–910.
- Crocker, J., Luhtanen, R. K., Cooper, M. L., & Bouvrette, A. (2003). Contingencies of self-worth in college students: Theory and measurement. *Journal of Personality and Social Psychology*, 85(5), 894–908. <https://doi.org/10.1037/0022-3514.85.5.894>
- Crowne, D. P., & Marlowe, D. (1960). A new scale of social desirability independent of psychopathology. *Journal of Consulting Psychology*, 24(4), 349.
- Dale, A. M. (1999). Optimal experimental design for event-related fMRI. *Human Brain Mapping*, 8(2–3), 109–114.
- Diaz, B. A., Van Der Sluis, S., Moens, S., Benjamins, J. S., Migliorati, F., Stoffers, D., ... Linkenkaer-Hansen, K. (2013). The Amsterdam Resting-State Questionnaire reveals

- multiple phenotypes of resting-state cognition. *Frontiers in Human Neuroscience*, 7.
<https://doi.org/10.3389/fnhum.2013.00446>
- Ellenbogen, J. M., Hu, P. T., Payne, J. D., Titone, D., & Walker, M. P. (2007). Human relational memory requires time and sleep. *Proceedings of the National Academy of Sciences*, 104(18), 7723–7728. <https://doi.org/10.1073/pnas.0700094104>
- Epley, N., Waytz, A., & Cacioppo, J. (2007). On seeing human: a three-factor theory of anthropomorphism. *Psychological Review*, 114(4), 864.
- Fachechi, A., Agliari, E., & Barra, A. (2019). Dreaming neural networks: Forgetting spurious memories and reinforcing pure ones. *Neural Networks*, 112, 24–40.
<https://doi.org/10.1016/j.neunet.2019.01.006>
- Fan, J., McCandliss, B. D., Fossella, J., Flombaum, J. I., & Posner, M. I. (2005). The activation of attentional networks. *NeuroImage*, 26(2), 471–479.
<https://doi.org/10.1016/j.neuroimage.2005.02.004>
- Fantz, R. L. (1963). Pattern Vision in Newborn Infants. *Science*, 140(3564), 296–297.
<https://doi.org/10.1126/science.140.3564.296>
- Fiske, S. T., Gilbert, D. T., & Lindzey, G. (2010). *Handbook of Social Psychology*. John Wiley & Sons.
- Fox, K. C. R., Spreng, R. N., Ellamil, M., Andrews-Hanna, J. R., & Christoff, K. (2015). The wandering brain: Meta-analysis of functional neuroimaging studies of mind-wandering and related spontaneous thought processes. *NeuroImage*, 111, 611–621.
<https://doi.org/10.1016/j.neuroimage.2015.02.039>

- Gardner, W., Pickett, C., Jefferis, V., & Knowles, M. (2005). On the outside looking in: Loneliness and social monitoring. *Personality and Social Psychology Bulletin*, 31(11), 1549–1560.
- Gazzaniga, M. (2008). *The Seed Salon: Tom Wolfe + Michael Gazzaniga*.
- John, O. P., Naumann, L. P., & Soto, C. J. (2008). Paradigm shift to the integrative Big Five trait taxonomy: History, measurement, and conceptual issues. In *Handbook of personality: Theory and research*, 3rd ed (pp. 114–158). New York, NY, US: Guilford Press.
- Jolly, E., Tamir, D. I., Burum, B., & Mitchell, J. P. (2019). Wanting without enjoying: The social value of sharing experiences. *PLOS ONE*, 14(4), e0215318.
<https://doi.org/10.1371/journal.pone.0215318>
- Klinger, E. (1971). *Structure and functions of fantasy*. Oxford, England: Wiley-Interscience.
- Klinger, E. (2013). Goal Commitments and the content of thoughts and dreams: basic principles. *Frontiers Psychology*, 4, 415. <https://doi.org/10.3389/fpsyg.2013.00415>
- Krienen, F. M., Tu, P.-C., & Buckner, R. L. (2010). Clan Mentality: Evidence That the Medial Prefrontal Cortex Responds to Close Others. *The Journal of Neuroscience*, 30(41), 13906–13915. <https://doi.org/10.1523/JNEUROSCI.2180-10.2010>
- Leary, M. R., Kelly, K. M., Cottrell, C. A., & Schreindorfer, L. S. (2013). Construct Validity of the Need to Belong Scale: Mapping the Nomological Network. *Journal of Personality Assessment*, 95(6), 610–624. <https://doi.org/10.1080/00223891.2013.819511>
- Lieberman, M. D. (2013). *Social: Why our brains are wired to connect*. New York, NY, US: Crown Publishers/Random House.
- Lombrozo, T., & Carey, S. (2006). Functional explanation and the function of explanation. *Cognition*, 99(2), 167–204. <https://doi.org/10.1016/j.cognition.2004.12.009>

- Lombrozo, T., & Gwynne, N. Z. (2014). Explanation and inference: Mechanistic and functional explanations guide property generalization. *Frontiers in Human Neuroscience*, 8.
<https://doi.org/10.3389/fnhum.2014.00700>
- Mar, R. A., Mason, M. F., & Litvack, A. (2012). How daydreaming relates to life satisfaction, loneliness, and social support: the importance of gender and daydream content. *Consciousness and Cognition*, 21(1), 401–407.
- Markus, H. (1978). The effect of mere presence on social facilitation: An unobtrusive test. *Journal of Experimental Social Psychology*, 14(4), 389–397.
- McVay, J. C., & Kane, M. J. (2012). Why does working memory capacity predict variation in reading comprehension? On the influence of mind wandering and executive attention. *Journal of Experimental Psychology: General*, 141(2), 302.
<https://doi.org/10.1037/a0025250>
- Meyer, M. L. (in press). Social by default: Characterizing the social functions of the resting brain. *Current Directions in Psychological Science*.
- Meyer, M. L., Davachi, L., Ochsner, K. N., & Lieberman, M. D. (2018). Evidence That Default Network Connectivity During Rest Consolidates Social Information. *Cerebral Cortex*.
<https://doi.org/10.1093/cercor/bhy071>
- Mildner, J. N., & Tamir, D. I. (2018, December 10). Spontaneous thought in social contexts.
Retrieved from osf.io/cew8b
- Miller, L. C., Murphy, R., & Buss, A. H. (1981). Consciousness of body: Private and public. *Journal of Personality and Social Psychology*, 41(2), 397–406.
<https://doi.org/10.1037/0022-3514.41.2.397>

- Morelli, S. A., Lieberman, M. D., & Zaki, J. (2015). The Emerging Study of Positive Empathy. *Social and Personality Psychology Compass*, 9(2), 57–68.
<https://doi.org/10.1111/spc3.12157>
- Northoff, G. (2018). How Does the Brain's Spontaneous Activity Generate Our Thoughts?: Spatiotemporal Theory of Task-Unrelated Thought (STTT). *The Oxford Handbook of Spontaneous Thought*. <https://doi.org/10.1093/oxfordhb/9780190464745.013.9>
- Pennebaker, J. W. (2015). *Linguistic inquiry and word count: LIWC2015*. Pennebaker Conglomerates.
- Pickett, C. L., Gardner, W. L., & Knowles, M. (2004). Getting a Cue: The Need to Belong and Enhanced Sensitivity to Social Cues. *Personality and Social Psychology Bulletin*, 30(9), 1095–1107. <https://doi.org/10.1177/0146167203262085>
- Poerio, G. L., Totterdell, P., Emerson, L.-M., & Miles, E. (2015). Love is the triumph of the imagination: Daydreams about significant others are associated with increased happiness, love and connection. *Consciousness and Cognition*, 33, 135–144.
<https://doi.org/10.1016/j.concog.2014.12.011>
- Poerio, G. L., Totterdell, P., Emerson, L.-M., & Miles, E. (2016). Helping the heart grow fonder during absence: Daydreaming about significant others replenishes connectedness after induced loneliness. *Cognition and Emotion*, 30(6), 1197–1207.
<https://doi.org/10.1080/02699931.2015.1049516>
- Quoidbach, J., Gruber, J., Mikolajczak, M., Kogan, A., Kotsou, I., & Norton, M. I. (2014). Emodiversity and the emotional ecosystem. *Journal of Experimental Psychology: General*, 143(6), 2057.

- Reichle, E. D., Reineberg, A. E., & Schooler, J. W. (2010). Eye Movements During Mindless Reading. *Psychological Science*, 21(9), 1300–1310.
<https://doi.org/10.1177/0956797610378686>
- Rosenberg, M. (1979). *Conceiving the self*. New York: Basic Books.
- Russell, D. W. (1996). UCLA Loneliness Scale (Version 3): Reliability, Validity, and Factor Structure. *Journal of Personality Assessment*, 66(1), 20.
- Schilbach, L., Bzdok, D., Timmermans, B., Fox, P. T., Laird, A. R., Vogeley, K., & Eickhoff, S. B. (2012). Introspective Minds: Using ALE Meta-Analyses to Study Commonalities in the Neural Correlates of Emotional Processing, Social & Unconstrained Cognition. *PloS One*, 7(2), e30920. <https://doi.org/10.1371/journal.pone.0030920>
- Schilbach, L., Eickhoff, S. B., Rotarska-Jagiela, A., Fink, G. R., & Vogeley, K. (2008). Minds at rest? Social cognition as the default mode of cognizing and its putative relationship to the “default system” of the brain. *Consciousness and Cognition*, 17(2), 457–467.
<https://doi.org/10.1016/j.concog.2008.03.013>
- Schmitt, B., Gilovich, T., Goore, N., & Joseph, L. (1986). Mere presence and social facilitation: One more time. *Journal of Experimental Social Psychology*, 22(3), 242–248.
- Senju, A. (2013). Atypical development of spontaneous social cognition in autism spectrum disorders. *Brain and Development*, 35(2), 96–101.
<https://doi.org/10.1016/j.braindev.2012.08.002>
- Song, X., & Wang, X. (2012). Mind wandering in Chinese daily lives—an experience sampling study. *PloS One*. <https://doi.org/10.1371/journal.pone.0044423>
- Spreng, R. N., & Grady, C. L. (2009). Patterns of Brain Activity Supporting Autobiographical Memory, Prospection, and Theory of Mind, and Their Relationship to the Default Mode

- Network. *Journal of Cognitive Neuroscience*, 22(6), 1112–1123.
<https://doi.org/10.1162/jocn.2009.21282>
- Spunt, R. P., Meyer, M. L., & Lieberman, M. D. (2015). The Default Mode of Human Brain Function Primes the Intentional Stance. *Journal of Cognitive Neuroscience*, 27(6), 1116–1124. https://doi.org/10.1162/jocn_a_00785
- Tambini, A., Ketz, N., & Davachi, L. (2010). Enhanced Brain Correlations during Rest Are Related to Memory for Recent Experiences. *Neuron*, 65(2), 280–290.
<https://doi.org/10.1016/j.neuron.2010.01.001>
- Tamir, D. I., & Hughes, B. L. (2018). Social Rewards: From Basic Social Building Blocks to Complex Social Behavior. *Perspectives on Psychological Science*, 13(6), 700–717.
<https://doi.org/10.1177/1745691618776263>
- Tamir, D. I., & Mitchell, J. P. (2012). Disclosing information about the self is intrinsically rewarding. *Proceedings of the National Academy of Sciences*, 109(21), 8038–8043.
<https://doi.org/10.1073/pnas.1202129109>
- Tamir, D. I., & Mitchell, J. P. (2013). Anchoring and adjustment during social inferences. *Journal of Experimental Psychology. General*, 142(1), 151–162.
<https://doi.org/10.1037/a0028232>
- U.S. Bureau of Labor Statistics. (2016). *American time use survey (2003–2016)*. Retrieved from https://www.bls.gov/tus/data/files_0316.htm
- Underwood, L. G. (2006). Ordinary Spiritual Experience: Qualitative Research, Interpretive Guidelines, and Population Distribution for the Daily Spiritual Experience Scale. *Archive for the Psychology of Religion*, 28(1), 181–218.
<https://doi.org/10.1163/008467206777832562>

- Vallacher, R. R., & Wegner, D. M. (1989). Levels of personal agency: Individual variation in action identification. *Journal of Personality and Social Psychology*, 57(4), 660.
- Wamsley, E. J. (2019). Memory Consolidation during Waking Rest. *Trends in Cognitive Sciences*, 23(3), 171–173. <https://doi.org/10.1016/j.tics.2018.12.007>
- Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, 54(6), 1063. <https://doi.org/10.1037/0022-3514.54.6.1063>
- Webster, D. M., & Kruglanski, A. W. (1994). Individual Differences in Need for Cognitive Closure. *Journal of Personality and Social Psychology*, 67(6), 1049–1062.
- Welborn, B. L., & Lieberman, M. D. (2014). Person-specific Theory of Mind in Medial pFC. *Journal of Cognitive Neuroscience*, 27(1), 1–12. https://doi.org/10.1162/jocn_a_00700
- Williams, J. J., & Lombrozo, T. (2010). The Role of Explanation in Discovery and Generalization: Evidence From Category Learning. *Cognitive Science*, 34(5), 776–806. <https://doi.org/10.1111/j.1551-6709.2010.01113.x>
- Williams, W. C., Morelli, S. A., Ong, D. C., & Zaki, J. (2018). Interpersonal emotion regulation: Implications for affiliation, perceived support, relationships, and well-being. *Journal of Personality and Social Psychology*, 115(2), 224–254. <https://doi.org/10.1037/pspi0000132>
- Zajonc, R. B. (1965). Social facilitation. *Science*, 149(3681), 269–274.
- Zhao, X., Cusimano, C. J., & Malle, B. F. (2015). In Search of Triggering Conditions for Spontaneous Visual Perspective Taking. *Proceedings of the 37th Annual Conference of the Cognitive Science Society*, 2811–2816.

Zhao, Z., Thornton, M. A., & Tamir, D. I. (in press). Accurate emotion prediction in dyads and groups and its potential social benefits. *Emotion*.

Supplemental Information for

The people around you are inside your head: Social context shapes spontaneous thought

Judith N. Mildner and Diana I. Tamir

Address correspondence to:

Judith Mildner

Email: jmildner@princeton.edu

Supplemental Information

We collected several measures for exploratory purposes that were not reported in the manuscript. All data is available online on the Open Science Framework (<https://osf.io/cew8b/>), with the exception of free response data that can contain personally identifiable information.

Study 1

Methods

During the mind wandering task, the text was displayed in chunks of 2-3 complete sentences (about 400-500 characters) to ensure it would fit on the screen in easy-to-read sections. The timing of the probes was determined by generating a random number of seconds between 120 and 240 for each probe. Participants advanced the text by pressing the space bar and could return to previous pages by pressing backspace.

For the subjective measure of social thought, we excluded raters who had a standard deviation of 10 or less in all of their ratings. We set this criterium a priori to exclude raters who choose the same response every time. The effect of this rule was minimal, resulting in 8 exclusions out of 300 raters for Study 2 and no exclusions for Study 1 and Study 3.

Table 1. Mind wandering task statistics for Study 1

Condition	Number of participants	Average number of trials per participant (SD)	Rate of self-reported mind wandering (SD)	Average number of characters (SD)	Average number of words (SD)
Solitude	36	10.89 (2.58)	0.33 (0.24)	122.4 (138.5)	22.7 (25.7)
Control	43	11.02 (2.65)	0.38 (0.25)	130.2 (115.1)	24.1 (21.0)

Additional Results

Responses from the mind wandering task were not just rated on social content, but also on task-related content, memory-based simulation, introspection, and semantic information. There was a significant interaction effect between mind wandering and condition for the ratings of memory-based simulation ($\beta = -10.05$, $SE = 3.01$, $p < 0.001$), such that participants in the solitude condition showed fewer memory-based thoughts during mind wandering (Mind wandering $M_{control} = 47.18$, $SD_{control} = 25.26$, $M_{solitude} = 36.02$, $SD_{solitude} = 22.04$; No mind wandering $M_{control} = 27.74$, $SD_{control} = 17.59$, $M_{solitude} = 25.88$, $SD_{solitude} = 16.12$). The effect of solitude was limited to social thought and memory, as there were no significant interaction effects for the ratings of task-related content ($\beta = -.25$, $SE = 3.33$, $p = 0.94$), introspection ($\beta = 1.05$, $SE = 3.24$, $p = 0.75$), or semantic information ($\beta = -.30$, $SE = 2.33$, $p = 0.90$).

In the fMRI analysis, we conducted exploratory analyses testing for an interaction between condition (isolated vs. control) and target (friend vs. Obama, and friend vs. self). The results support the social processing hypothesis: the difference in activation in the mentalizing network between the friend and Obama targets was larger for control participants than isolated participants ($M_{solitude} = -0.181$, $M_{control} = 0.286$, $t(78.561) = 3.63$, $p < 0.001$). The difference in activation for the friend and self target was also larger for control participants than isolated participants ($M_{solitude} = 0.544$, $M_{control} = 0.786$, $t(75.172) = 2.30$, $p = 0.024$).

Additional Measures

We included several measures for exploratory individual differences analyses were included in this study. All measures not discussed in the main text are listed below. Participants completed a survey approximately one week in advance of the study, hourly surveys at the start

of the study and each hour for 6 hours, and an exit survey at the end of the study, after fMRI scanning.

Survey Data. The initial survey taken in advance of the study included some measures administered only once: the Big Five Inventory (John, Naumann, & Soto, 2008), Inclusion of Other in the Self task (Aron, Aron, & Smollan, 1992) using the name of the friend also used in the social inferences task during scanning, and questions on typical daily social life and social media use. The latter consisted of participants indicating how many hours per day on average they spent asleep, awake and alone, around other people but not interacting, and interacting with others, and how many times per day they sent texts/instant messages, emails, and checked social media.

Other items in the initial survey were repeated in the exit survey at the conclusion of the study. These measures were the Rosenberg Self-Esteem scale (Rosenberg, 1979), Contingencies of Self-Worth Scale (Crocker, Luhtanen, Cooper, & Bouvrette, 2003), Daily Spiritual Experiences Scale (Underwood, 2006), Visual Perspective Taking (Zhao, Cusimano, & Malle, 2015), Empathy Quotient (Baron-Cohen & Wheelwright, 2004), UCLA Loneliness scale (Russell, 1996), Need to Belong scale (Leary, Kelly, Cottrell, & Schreindorfer, 2013), and Interpersonal Regulation Questionnaire (W. C. Williams, Morelli, Ong, & Zaki, 2018).

The exit survey also contained measures not included in the initial survey. These were the Valence-Arousal Emotional graph, Domain vs. Causal History task (Lombrozo & Carey, 2006), Patterns of Generalization (Lombrozo & Gwynne, 2014), Liking for ambiguous and unambiguous figures, Need for Closure – Ambiguity subscale (Webster & Kruglanski, 1994), Self-Ratings of Personality, Emodiversity (Quoidbach et al., 2014), Behavior Identification Form (Vallacher & Wegner, 1989), Anchoring and Adjustment Questionnaire, Category Learning (J. J.

Williams & Lombrozo, 2010), Social Desirability (Crowne & Marlowe, 1960), Religious Orientation Scale (Allport & Ross, 1967), Body Consciousness Scale (Miller, Murphy, & Buss, 1981), and an anthropomorphism measure in which two abstract objects were presented and participants were asked to write a short story using those two objects.

Participants completed 7 short surveys throughout the day, one at the start of the experiment (hour 0), and one at the end of every hour for the subsequent 6 hours. These surveys consisted of a free response prompt (“Please write down any comments, remarks, or notes.”) and the Positive and Negative Affect Scale (PANAS; (Watson, Clark, & Tellegen, 1988). At four timepoints – hours 0, 2, 4, and 6 – the survey also included an anthropomorphism measure. This consisted of three abstract objects, presented one-by-one, with the open-ended question: “What does this object look like?”. For the control group, these surveys also included questions about what they did in the last hour. Control participants were asked how much time in the last hour they had spent alone, around other people but not interacting, interacting with others in person, and asleep. They were also asked how many times in the past hour they texted or instant messaged someone, checked social media, or emailed someone, followed by an open ended item: “What did you do since the last survey?”

fMRI. In addition to the social inferences task reported in the manuscript, participants completed several other tasks during fMRI scanning. Participants first did the Attention Network Task (Fan, McCandliss, Fossella, Flombaum, & Posner, 2005). Then, in counterbalanced order, participants did either the social inferences task or a sharing task. In the sharing task, participants answered questions about themselves. The questions were preference statements, like in the social inferences task. On half the trials, the question appeared under the word PRIVATE, in the other half it appeared under the word SHARED. Participants were told that when the word

SHARED was on the screen their responses would be shared with future participants and the experimenter in the next room, while PRIVATE trials would not be shared with anyone. Finally, participants completed a resting state scan.

Study 2

Table 2. Mind wandering task statistics for Study 2

Condition	Number of participants	Average number of trials per participant (SD)	Rate of self-reported mind wandering (SD)	Average number of characters (SD)	Average number of words (SD)
Social presence	43	12.33 (1.22)	0.37 (0.26)	140.6 (102.3)	25.9 (19.1)
Control	42	12.52 (1.36)	0.40 (0.24)	147.7 (130.6)	27.3 (23.8)

Additional Results

Since the parametric analysis method yielded null results, we ran a Bayesian version of the same models to assess evidence for the null hypothesis. To do this, we compared the model used in the main analysis, with a null model that did not include the interaction effect. This showed substantial evidence for the null model ($BF_{01} = 8.40$). As such, the Bayesian analyses support the findings from the parametric analyses: there is no effect of the social presence on spontaneous social thought.

Responses from the mind wandering task were not just rated by mTurk participants on social content, but also on task-related content, memory-based simulation, introspection, and semantic information. The ratings of semantic information showed poor inter-rater reliability and were not analyzed for this study.

Memory-based simulation shows a significant interaction effect ($\beta = -7.04$, $SE = 2.99$, $p = 0.02$; Mind wandering $M_{control} = 54.1$, $SD_{control} = 26.05$, $M_{social\ presence} = 47.90$, $SD_{social\ presence} =$

24.77; No mind wandering $M_{control} = 39.1$, $SD_{control} = 21.01$, $M_{social\ presence} = 39.37$, $SD_{social\ presence} = 20.7$), such that social presence decreased memory-based thought, contrary to expectations. Mere social presence did not affect task-related content ($\beta = -2.34$, $SE = 2.48$, $p = 0.35$), or introspection ($\beta = 2.01$, $SE = 2.77$, $p = 0.47$). The ratings of semantic information showed poor inter-rater reliability and were not analyzed for this study.

Additional Measures

In Study 2, participants completed a short survey after the mind wandering task including the UCLA loneliness scale, need to belong scale, and IRQ as described in Study 4. This survey also included the PANAS (Watson et al., 1988), and a moral word search task in which participants were asked to list the first five words they found in a word search containing both moral and non-moral words.

Study 3

Table 3. Mind wandering task statistics for Study 3

Condition	Number of participants	Average number of trials per participant	Rate of self-reported mind wandering	Average number of characters	Average number of words
Social interaction	42	11.62 (1.32)	0.38 (0.24)	152.7 (122.8)	28.1 (23.4)
Control	40	12.00 (1.50)	0.42 (0.22)	161.9 (113.0)	29.4 (20.3)

Additional Results

Responses from the mind wandering task were not just rated on social content, but also on task-related content, memory-based simulation, introspection, and semantic information. The

effect of social interaction was limited to social thought, as there were no interaction effects for memory-based simulation ($\beta = -.40$, $SE = 2.66$, $p = 0.88$), introspection ($\beta = -2.04$, $SE = 2.93$, $p = 0.39$), or task-related content ($\beta = -2.92$, $SE = 2.74$, $p = 0.29$).

Additional Measures

In addition to the UCLA loneliness scale, need to belong scale, and IRQ discussed in Study 4, participants also completed the PANAS after the mind wandering task.

Study 4

Additional Analyses

To further unpack the results from Study 4, we correlated each social needs measure with social thought during mind wandering and social thought when not mind wandering. For each participant, we calculated the means of their objective and subjective social thought scores across all of trials where they reported mind wandering and across all trials where they reported not mind wandering. Since participants, on average, had more trials where they were not mind wandering than trials where they were mind wandering, the variance for the estimates during mind wandering is higher (subjective social thought: $M_{\text{no mind wandering}} = 14.68$, $SD_{\text{no mind wandering}} = 6.97$, $M_{\text{mind wandering}} = 16.62$, $SD_{\text{mind wandering}} = 12.31$; objective social thought: $M_{\text{no mind wandering}} = 4.51$, $SD_{\text{no mind wandering}} = 3.17$, $M_{\text{mind wandering}} = 3.99$, $SD_{\text{mind wandering}} = 3.33$).

Although there was no significant interaction effect for any of the survey variables with self-reported mind wandering, the relations between the survey measures and the objective measure of social thought are most prominent when participants are not mind wandering. The following correlations were all corrected for multiple comparisons using FDR correction. When

analyzing only not-mind wandering trials, there is a negative correlation between objective social thought and loneliness ($r = -.21, n = 111, p = 0.03$), and positive correlations between objective social thought and need to belong ($r = .27, n = 123, p = 0.003$) and all four IRQ subscales (tendency-negative $r = .16, n = 123, p = 0.07$; tendency-positive $r = .22, n = 123, p = 0.02$; efficacy-negative $r = .15, n = 122, p = 0.11$; efficacy-positive $r = .15, n = 123, p = 0.09$). On trials where participants did report mind wandering, the IRQ subscales each show positive correlations with objective social thought as well (tendency-negative $r = .25, n = 118, p = 0.01$; tendency-positive $r = .18, n = 118, p = 0.05$; efficacy-negative $r = .22, n = 117, p = 0.02$; efficacy-positive $r = .22, n = 118, p = 0.02$). However, loneliness and need to belong are not significantly correlated with objective social thought during mind wandering (loneliness $r = -.11, n = 106, p = 0.27$; need to belong $r = .1, n = 118, p = 0.3$).

Additionally, participants who had higher loneliness scores reported mind wandering more frequently ($r = .29, n = 112, p = 0.008$).

Need to belong correlates at .5-.6 with the IRQ subscales. Loneliness does not significantly correlate with need to belong ($.16, p = .1$) or any of the IRQ subscales except efficacy-positive ($-.2, p = .03$).

Table 4. Correlations between all variables

	1. Social content overall (objective)	2. Social content during mind wandering (objective)	3. Social content - not mind wandering (objective)	4. Social content overall (subjective)	5. Social content during mind wandering (subjective)	6. Social content - not mind wandering (subjective)	7. Need to belong	8. Loneliness	9. IRQ (Tendency Negative)	10. IRQ (Tendency Positive)	11. IRQ (Efficacy Negative)	12. IRQ (Efficacy Positive)
2	0.56***											
3	0.81***	0.12										
4	0.11	0.12	0.02									
5	0.25**	0.41***	0.08	0.67***								
6	0.00	-0.13	0.11	0.77***	0.26**							
7	0.26**	0.10	0.27**	0.01	-0.08	0.04						
8	-0.22*	-0.11	-0.21*	-0.03	-0.07	-0.08	0.15					
9	0.25**	0.25**	0.16	0.03	-0.08	0.03	0.59***	-0.01				
10	0.31***	0.18	0.22*	-0.06	-0.05	-0.10	0.51***	-0.04	0.63***			
11	0.25**	0.22*	0.14	0.02	-0.08	-0.02	0.65***	-0.10	0.72***	0.66***		
12	0.25**	0.22*	0.15	-0.04	-0.02	-0.15	0.53***	-0.23*	0.56***	0.63***	0.59***	

Mini Meta-Analysis (Studies 1-3)**Methods**

Since the first 3 studies all contained the same variables and analysis models, we combined the analyses into one model. Like the study specific models, this model included fixed effects for mind wandering, condition, and the interaction between mind wandering and condition. The model also contained random intercepts for participant and study.

Results

In line with the results from the individual models, there were significant interaction effects between mind wandering and condition. The interaction between mind wandering and being in the solitude condition was negative (subjective measure: $\beta = -4.89$, $SE = 2.00$, $p = 0.01$; objective measure: $\beta = -3.16$, $SE = 0.71$, $p < 0.001$), while the interaction between mind wandering and being in the social interaction condition was positive (subjective measure: $\beta = 6.07$, $SE = 1.72$, $p < 0.001$;

objective measure: $\beta = 3.52$, $SE = 0.64$, $p < 0.001$). There were no significant interaction effects between mind wandering and being in the social presence condition (subjective measure: $\beta = 0.17$, $SE = 1.70$, $p = 0.92$; objective measure: $\beta = 0.90$, $SE = 0.62$, $p = 0.15$).

References

- Allport, G. W., & Ross, J. M. (1967). Personal religious orientation and prejudice. *Journal of Personality and Social Psychology*, 5(4), 432.
- Aron, A., Aron, E. N., & Smollan, D. (1992). Inclusion of other in the self scale and the structure of interpersonal closeness. *Journal of Personality and Social Psychology*, 63(4), 596.
- Baron-Cohen, S., & Wheelwright, S. (2004). The empathy quotient: An investigation of adults with Asperger syndrome or high functioning autism, and normal sex differences. *Journal of Autism and Developmental Disorders*, 34(2), 163–175.
- Crocker, J., Luhtanen, R. K., Cooper, M. L., & Bouvrette, A. (2003). Contingencies of self-worth in college students: Theory and measurement. *Journal of Personality and Social Psychology*, 85(5), 894–908. <https://doi.org/10.1037/0022-3514.85.5.894>
- Crowne, D. P., & Marlowe, D. (1960). A new scale of social desirability independent of psychopathology. *Journal of Consulting Psychology*, 24(4), 349.
- Fan, J., McCandliss, B. D., Fossella, J., Flombaum, J. I., & Posner, M. I. (2005). The activation of attentional networks. *NeuroImage*, 26(2), 471–479.
<https://doi.org/10.1016/j.neuroimage.2005.02.004>
- John, O. P., Naumann, L. P., & Soto, C. J. (2008). Paradigm shift to the integrative Big Five trait taxonomy: History, measurement, and conceptual issues. In *Handbook of personality: Theory and research*, 3rd ed (pp. 114–158). New York, NY, US: Guilford Press.
- Leary, M. R., Kelly, K. M., Cottrell, C. A., & Schreindorfer, L. S. (2013). Construct Validity of the Need to Belong Scale: Mapping the Nomological Network. *Journal of Personality Assessment*, 95(6), 610–624. <https://doi.org/10.1080/00223891.2013.819511>

- Lombrozo, T., & Carey, S. (2006). Functional explanation and the function of explanation. *Cognition*, 99(2), 167–204. <https://doi.org/10.1016/j.cognition.2004.12.009>
- Lombrozo, T., & Gwynne, N. Z. (2014). Explanation and inference: Mechanistic and functional explanations guide property generalization. *Frontiers in Human Neuroscience*, 8. <https://doi.org/10.3389/fnhum.2014.00700>
- Miller, L. C., Murphy, R., & Buss, A. H. (1981). Consciousness of body: Private and public. *Journal of Personality and Social Psychology*, 41(2), 397–406. <https://doi.org/10.1037/0022-3514.41.2.397>
- Quoidbach, J., Gruber, J., Mikolajczak, M., Kogan, A., Kotsou, I., & Norton, M. I. (2014). Emodiversity and the emotional ecosystem. *Journal of Experimental Psychology: General*, 143(6), 2057.
- Rosenberg, M. (1979). *Conceiving the self*. New York: Basic Books.
- Russell, D. W. (1996). UCLA Loneliness Scale (Version 3): Reliability, Validity, and Factor Structure. *Journal of Personality Assessment*, 66(1), 20.
- Underwood, L. G. (2006). Ordinary Spiritual Experience: Qualitative Research, Interpretive Guidelines, and Population Distribution for the Daily Spiritual Experience Scale. *Archive for the Psychology of Religion*, 28(1), 181–218. <https://doi.org/10.1163/008467206777832562>
- Vallacher, R. R., & Wegner, D. M. (1989). Levels of personal agency: Individual variation in action identification. *Journal of Personality and Social Psychology*, 57(4), 660.
- Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, 54(6), 1063. <https://doi.org/10.1037/0022-3514.54.6.1063>

- Webster, D. M., & Kruglanski, A. W. (1994). Individual Differences in Need for Cognitive Closure. *Journal of Personality and Social Psychology*, 67(6), 1049–1062.
- Williams, J. J., & Lombrozo, T. (2010). The Role of Explanation in Discovery and Generalization: Evidence From Category Learning. *Cognitive Science*, 34(5), 776–806.
<https://doi.org/10.1111/j.1551-6709.2010.01113.x>
- Williams, W. C., Morelli, S. A., Ong, D. C., & Zaki, J. (2018). Interpersonal emotion regulation: Implications for affiliation, perceived support, relationships, and well-being. *Journal of Personality and Social Psychology*, 115(2), 224–254.
<https://doi.org/10.1037/pspi0000132>
- Zhao, X., Cusimano, C. J., & Malle, B. F. (2015). In Search of Triggering Conditions for Spontaneous Visual Perspective Taking. *Proceedings of the 37th Annual Conference of the Cognitive Science Society*, 2811–2816.