Beyond Memory: Goal-Structured Dynamics in Spontaneous Thought

Recent research on spontaneous thought has been shaped by two converging trends: an emphasis on memory as the core underlying mechanism and a growing interest in its dynamics—the way one thought gives rise to the next within a temporally extended spontaneous thought stream. This paper argues that these trends, when combined, reveal a fundamental gap in current theorizing. While memory-based accounts can explain the content of spontaneous thought, they provide an incomplete account of its dynamics because they overlook a distinct mode of organization: goal-structured dynamics, in which cognitive control actively shapes how the stream of thought unfolds.

The content/dynamics distinction. Following the dynamic framework of Christoff et al. (2016), I treat spontaneous thought as a temporally extended phenomenon whose explanatory target includes not only ***what*** is thought (content) but ***how*** successive thoughts are selected and connected (dynamics). The same content can appear in very different streams: one governed by associative drift, another embedded in deliberate planning. Thought-transition dynamics constitutes a dimension of the explanandum distinct from, and irreducible to, content. As I will argue, it is precisely this dynamic dimension that reveals the insufficiency of memory accounts.

Memory accounts and their shared limitation. A recently emerging family of memory accounts shares a foundational commitment: specific memory mechanisms lie at the core of spontaneous thought. By reducing spontaneous thought to well-studied memory processes, theorists aim to leverage our understanding of memory to illuminate the less-understood phenomenon of spontaneous thought. Despite their heterogeneity, these accounts converge on a systematic blind spot: cognitive control is excluded from the story of how spontaneous thought unfolds. I briefly review several representative memory accounts: the SWR-trigger hypothesis (O'Callaghan et al., 2021), the consolidation-reflection view (Wamsley, 2019), the pattern-completion account (Mills et al., 2018), and the unconstrained memory framework (Mildner & Tamir, 2019, 2024). Those that address dynamics characterize thought transitions as fundamentally associative.

Goals as content versus goals as organizers. The unconstrained memory framework, the most sophisticated and comprehensive memory account, can accommodate two well-known types of spontaneous thought content: goal-related and future-oriented content. According to the framework, current concerns can modulate associative retrieval: pending goals have heightened accessibility within the associative memory structure (Klinger, 2013), and pre-formed plans can enter consciousness via control-free associative retrieval as "memories of the future" (Cole & Kvavilashvili, 2019). However, there is a crucial distinction between a goal's entering consciousness, which is a matter of content, and a goal's organizing the thought stream across multiple transitions, which is a matter of dynamics. An activated goal might simply drift away via association, or it might be elaborated into a goal-directed process, e.g., making a plan during spontaneous thought. These possibilities cannot be distinguished by looking at content alone.

Associative dynamics versus goal-structured dynamics. I introduce a distinction between two modes of thought-transition dynamics. In associative dynamics, next thought selection is local: the immediate predecessor thought, together with modulatory weights, determines the next thought via the strongest available association. In goal-structured dynamics, next thought selection is non-local: a maintained goal representation, which I term an organizing goal, exerts a stable influence across multiple transitions, with each successor thought selected by its instrumental relevance to advancing the goal. Instrumental relevance is the selection criterion; means-end coherence is the observable structural pattern this criterion produces.

I argue that this distinction is irreducible. The objection that goal-structured dynamics can be reconstructed as a strong modulatory bias within the associative framework fails because the two modes implement structurally different selection principles. Modulatory bias changes which candidate wins a local associative competition, but cannot introduce a non-local representation that governs selection across multiple steps. The distinction receives independent support from the model-based/model-free distinction in reinforcement learning (Daw et al., 2005).

Goal-structured dynamics in spontaneous thought. I then demonstrate that goal-structured dynamics is a recurring feature of spontaneous thought through two empirical routes.

First, I address a pervasive ambiguity in the literature: most studies operationalize "planning during mind wandering" as goal-related, future-oriented **content** without assessing whether the thought stream exhibits the instrumental relevance structure characteristic of actual planning. I then present evidence for a **spontaneous planning hypothesis**, suggesting that genuine planning, which involves cognitive control, occurs during spontaneous thought: future-oriented mind wandering (a type of spontaneous thought) involves more inner speech and structured sequences (Stawarczyk et al., 2013), is sensitive to executive resources and working memory capacity (Smallwood et al., 2009; Baird et al., 2011), co-activates the default and frontoparietal control networks (Spreng et al., 2010), and refines personal goals toward greater concreteness (Medea et al., 2018).

Second, conversational simulation (or imagined interactions (Honeycutt, 2003)), imagining anticipated or past communicative encounters, provides a second route. I argue that simulating a conversation requires control to maintain a dialogic frame as an organizing goal that constrains transitions: successor thoughts are selected by relevance to the simulated exchange, not by associative strength. Supporting evidence includes the dominance of social content in spontaneous thought, with participants frequently reporting that they put themselves in others' shoes (Mar et al., 2012; Diaz et al., 2013), the prevalence of imagined interactions in diary studies (Honeycutt et al., 2014), and the neural overlap between dialogic inner speech and default network regions, which are reliably activated during spontaneous thought (Alderson-Day et al., 2016).

A dual-driver framework. These arguments motivate a hybrid account of spontaneous thought in which memory and cognitive control are both important. Memory supplies representational materials and associative pathways; control—automatically recruited in at least some cases—

maintains organizing goals that shape the stream. The two interact dynamically: an associatively cued concern can recruit control when elaborated into, for example, planning, and a control-guided sequence can dissolve into associative drift when the goal loses salience. I propose that the alternation between **an associative exploration regime** and **a goal-structured pursuit** regime is a functional feature of spontaneous thought. Finally, I argue that the field's recent methodological innovations (e.g., the free-association semantic tasks, thinking-aloud protocols) are insensitive to goal-structured dynamics due to their conceptual limitations, and call for a reconceptualization and refinement of these methods.

References

Alderson-Day, B., Weis, S., McCarthy-Jones, S., Moseley, P., Smailes, D., & Fernyhough, C. (2016). The brain's conversation with itself: Neural substrates of dialogic inner speech. Social Cognitive and Affective Neuroscience, 11(1), 110–120. https://doi.org/10.1093/scan/nsv094

Baird, B., Smallwood, J., & Schooler, J. W. (2011). Back to the future: Autobiographical planning and the functionality of mind-wandering. Consciousness and Cognition, 20(4), 1604–1611. https://doi.org/10.1016/j.concog.2011.08.007

Christoff, K., Irving, Z. C., Fox, K. C. R., Spreng, R. N., & Andrews-Hanna, J. R. (2016). Mind-wandering as spontaneous thought: A dynamic framework. Nature Reviews Neuroscience, 17(11), 718–731. https://doi.org/10.1038/nrn.2016.113

Cole, S. N., & Kvavilashvili, L. (2019). Spontaneous future cognition: The past, present and future of an emerging topic. Psychological Bulletin, 145(5), 477–498. https://doi.org/10.1037/bul0000185

Daw, N. D., Niv, Y., & Dayan, P. (2005). Uncertainty-based competition between prefrontal and dorsolateral striatal systems for behavioral control. Nature Neuroscience, 8(12), 1704–1711. https://doi.org/10.1038/nn1560

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, 446. https://doi.org/10.3389/fnhum.2013.00446

Honeycutt, J. M. (2003). Imagined interactions: Daydreaming about communication. Hampton Press.

Klinger, E. (2013). Goal commitments and the content of thoughts and dreams: Basic principles. Frontiers in Psychology, 4, 415. https://doi.org/10.3389/fpsyg.2013.00415

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. https://doi.org/10.1016/j.concog.2011.08.001

Medea, B., Karapanagiotidis, T., Konishi, M., Ottaviani, C., Margulies, D., Bernasconi, A., Bernasconi, N., Bernhardt, B. C., Jefferies, E., & Smallwood, J. (2018). How do we decide what to do? Resting-state connectivity patterns and components of self-generated thought linked to the development of more concrete personal goals. Experimental Brain Research, 236, 2469–2481. https://doi.org/10.1007/s00221-016-4729-y

Mildner, J. N., & Tamir, D. I. (2019). Spontaneous thought as an unconstrained memory process. Trends in Neurosciences, 42(11), 763–777. https://doi.org/10.1016/j.tins.2019.09.001

Mildner, J. N., & Tamir, D. I. (2024). The content of our thoughts tracks an unconstrained memory process. PNAS Nexus, 3(7), pgae230. https://doi.org/10.1093/pnasnexus/pgae230

Mills, C., Herrera-Bennett, A., Faber, M., & Christoff, K. (2018). Why the mind wanders: How spontaneous thought's default variability may support episodic efficiency and semantic optimization. In K. Christoff & K. C. R. Fox (Eds.), The Oxford handbook of spontaneous thought: Mind-wandering, creativity, and dreaming (pp. 11–22). Oxford University Press.

O'Callaghan, C., Shine, J. M., Lewis, S. J. G., Andrews-Hanna, J. R., & Irish, M. (2021). Shaped by our thoughts: A new task to assess spontaneous cognition and its associated neural correlates in the default network. Brain and Cognition, 93, 1–10. [Note: The Trends in Cognitive Sciences 2021 paper may be a different O'Callaghan reference—please verify against your intended citation]

Smallwood, J., Nind, L., & O'Connor, R. C. (2009). When is your head at? An exploration of the factors associated with the temporal focus of the wandering mind. Consciousness and Cognition, 18(1), 118–125. https://doi.org/10.1016/j.concog.2008.11.004

Spreng, R. N., Stevens, W. D., Chamberlain, J. P., Gilmore, A. W., & Schacter, D. L. (2010). Default network activity, coupled with the frontoparietal control network, supports goal-directed cognition. NeuroImage, 53(1), 303–317. https://doi.org/10.1016/j.neuroimage.2010.06.016

Stawarczyk, D., Cassol, H., & D'Argembeau, A. (2013). Phenomenology of future-oriented mind-wandering episodes. Frontiers in Psychology, 4, 425. https://doi.org/10.3389/fpsyg.2013.00425

Wamsley, E. J. (2019). Dreaming and offline memory consolidation. Current Neurology and Neuroscience Reports, 19, 27. https://doi.org/10.1007/s11910-019-0945-5methods.