Cognitive mechanisms of episodic simulation in psychiatric populations

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ABSTRACT

Episodic simulation is the construction of a mental representation of a specific autobiographical future event. Episodic simulation has increasingly been studied in psychiatric populations. Here we 1) review evidence indicating that episodic simulation is compromised in patients with depression, anxiety, schizophrenia, bipolar disorder, and PTSD; and 2) consider several potential cognitive mechanisms of episodic simulation in psychiatric populations: episodic retrieval, scene construction, mental imagery, components of the CaRFAX model (i.e., capture and ruminative, functional avoidance, and executive functioning), and narrative style. We evaluate evidence regarding these mechanisms across psychiatric populations, and identify areas of future research. Understanding the factors that contribute to episodic simulation impairment in psychiatric populations may lead to targeted and effective treatment approaches.

1. Introduction

Prospection is defined as the ability to mentally represent what might happen in the future (Gilbert & Wilson, 2007; Seligman, Railton, Baumeister, & Sripada, 2013; Szpunar, Spreng, & Schacter, 2014). Prospection, also sometimes referred to as “episodic future thinking” (Atance & O’Neill, 2001; Schacter, Benoit, & Szpunar, 2017), has become an increasingly important topic of research in psychology and neuropsychology during the past two decades. Szpunar et al. (2014) proposed a framework that distinguishes among four major forms of prospection: simulation, prediction, intention, and planning. They also delineate episodic and semantic forms in each domain of prospection, where episodic refers to specific autobiographical events in the future, and semantic refers to general or abstract states of the world in the future.

The focus of the current paper is on episodic simulation, defined as the construction of a mental representation of a specific autobiographical future event (also referred to as “future simulation” below) (Atance & O’Neill, 2001; Schacter, Addis, & Buckner, 2008; Szpunar, 2010; Szpunar et al., 2014). Much of the early work on episodic simulation stemmed from investigations of episodic simulation deficits in psychiatric conditions such as in individuals with dysphoria (MacLeod & Crolley, 1995) and suicidal patients (Williams et al., 1996). Subsequently, cognitive psychologists and neuropsychologists have extensively studied episodic simulation through investigation of its underlying cognitive mechanisms, its neural correlates, and disorders of episodic simulation in neurological populations (for reviews, see Buckner & Carroll, 2007; Irish & Piolino, 2016; Klein, 2013; Schacter & Addis, 2007; Schacter et al., 2012; Schacter et al., 2017; Ward, 2016).

Episodic simulation has been increasingly examined across psychiatric populations, including depression (Addis, Hach, & Tippett, 2016; Parlar et al., 2016), anxiety (Morina, Deeprose, Pusowski, Schmid, & Holmes, 2011; Wu, Szpunar, Godovich, Schacter, & Hofmann, 2015) bipolar disorder (Di Simplicio et al., 2016), schizophrenia (Raffard et al., 2016; Wang et al., 2017), and PTSD (Brown et al., 2016). Compromised episodic simulation has important clinical implications in psychiatric populations because of its relevance for various adaptive cognitive and behavioral functions, as well as for psychological well-being (Schacter et al., 2017). For example, brief training to increase the specificity of future simulations in a non-clinical population led to improved problem-solving for future worrisome events, reappraisal of negative outcomes, and decreased anxiety and negative affect within a test session (Jing, Madore, & Schacter, 2016). Engaging in future simulation has been linked to increased perceived control over future events (Boland, Rigg, & Anderson, 2018; Hallford, Yeow, et al., 2020) and anticipated pleasure for future events (Hallford, Farrell, & Lynch, 2020; Hallford, Yeow, et al., 2020). Additionally, future simulation has been associated with decision-making (Benoit, Gilbert, & Burgess, 2011; Peters & Büchel, 2010) and social problem-solving (Madore & Schacter, 2014). Interventions that improve specificity of future simulations may
allow patients with psychiatric conditions to better engage in and benefit from empirically-supported psychological interventions. For example, simulating the future increases the likelihood of completing an intended task (Altgassen et al., 2015; Neroni, Gamboz, & Brandimonte, 2014; Terrett et al., 2016), and planning future tasks or activities is a core component of cognitive behavioral therapy.

Research is in the early stages of investigating cognitive mechanisms that contribute to episodic simulation impairment in psychiatric disorders. The aim of this article is to review candidate cognitive mechanisms of episodic simulation impairment in psychiatric conditions based on the existing literature. Specifically, this paper will consider episodic simulation assessment and performance in the main psychiatric conditions in which episodic simulation has been studied: depression, anxiety, bipolar disorder, schizophrenia, and PTSD. Several distinguishable though related cognitive mechanisms of episodic simulation impairment in psychiatric conditions will be discussed: episodic memory retrieval, scene construction, mental imagery, components of the CaRFAX model (Williams, 2006; Williams et al., 2007) (capture and rumination, functional avoidance, and executive control dysfunction), and narrative style. A narrative review was conducted rather than a systematic review or meta-analysis because of the few number of studies per psychiatric condition and mechanism. Understanding the cognitive mechanisms of episodic simulation impairment in psychiatric populations can both help to advance theoretical analyses and inform interventions or cognitive rehabilitation in these populations.

2. Episodic simulation assessment and performance in psychiatric populations

2.1. Assessing episodic simulation in psychiatric populations

Researchers have assessed episodic simulation using both objective measures, which involve scoring descriptions of simulated future events based on specific criteria, and subjective measures, where participants rate their subjective experience (such as the level of detail or vividness) of an imagined future scenario. The main objective and subjective approaches to assessing episodic simulation are discussed below, though studies commonly use variants of these measures.

Objective measures of future simulation. The two main objective measures used to assess episodic simulation are the adapted Autobiographical Interview (AI) (Addis, Wong, & Schacter, 2008; Levine, Svovalski, Hay, Winocur, & Moscovitch, 2002) and the modified Autobiographical Memory Test (AMT) (Williams et al., 1996). Both the AI and AMT were originally devised to investigate memories of past personal experiences. In the adapted AI task and AMT, participants are given cues (a word or a short phrase), and in response to each cue they are asked to imagine and describe specific future events in as much detail as possible (and may also be asked to retrieve autobiographical memories). Some studies include valenced cues (positive, negative, and/or neutral cue words or phrases). In the adapted AI task, participant responses are coded based on the internal details and external details (Addis et al., 2008). Internal details are details tied to a specific time and place such as who will attend the event, what will occur, where the event will take place, and when the event will happen. External details include semantic knowledge, related facts, reflections on the event, off-topic details, repetitions, and references to other events. In the AMT, responses are coded based on the level of specificity of their future descriptions. Episodic simulation has also been assessed by measuring the coherence (Huddy, Drake, & Wykes, 2016) and clarity (Painter & Kring, 2016) of participants’ descriptions of future events.

A task related to the adapted AI task and the modified AMT is referred to as a scene construction task (Hassabis, Kumaran, Vann, & Maguire, 2007). Participants are asked to simulate both atemporal (i.e., scenarios not tied to the past or future; e.g., “Imagine you’re lying on a deserted white sandy beach in a beautiful tropical bay”) and future scenarios (e.g., “Imagine something you will be doing this weekend”) in response to short verbal cues. Responses are scored to determine the richness of the atemporal and future descriptions based on both subjective ratings of the participants’ experience and objective ratings by the researchers (Hassabis et al., 2007). Subjective ratings include participant ratings of the salience, sense of presence, and spatial coherence (an index incorporating ratings of the spatial integration of their simulation) of the simulated events. Objective components include the quality of the simulation and content included (i.e., spatial references, entities present, sensory descriptions, and thoughts/ emotions/actions). Overall richness of the atemporal and future descriptions is scored using an “experiential index,” which incorporates subjective and objective ratings.

Subjective measures of future simulation. Studies have also measured participants’ subjective experiences during episodic simulation. Early work measured the ability to “re-experience” the past and “pre-experience” the future in non-clinical populations (D’Argembeau & Van der Linden, 2004, 2006). Specifically, D’Argembeau and Van der Linden (2004) and D’Argembeau and Van der Linden (2006) asked participants to simulate specific events in the past and future in as much detail as possible, and then rate various aspects of their subjective experience using questionnaires adapted from memory research, such as the Memory Characteristics Questionnaire (Johnson, Foley, Suengas, & Raye, 1988) and the Autobiographical Memory Questionnaire (Rubin, Schnurf, & Greenberg, 2003). These measures or similar measures have been used in psychiatric populations. While there is variability between studies regarding what is subjectively rated by participants, participants are commonly asked to rate their subjective experience on the amount of overall detail, amount of sensory details (such as visual or auditory), clarity of location/spatial details, vividness, specificity, emotional intensity, emotional valence, visual perspective (field or observer), representation of the self (self-referential information), representation of others (other-referential information), and ability to “re-experience” the future simulation (such as “how well can you imagine experiencing the event?”) (for example, see Addis et al., 2016; Anderson & Evans, 2015; de Oliveira, Cuervo-Lombard, Salame, & Danion, 2009; Finnbogadottir & Bernsten, 2014; Painter & Kring, 2016; Raffard et al., 2016; Winfield & Kamboj, 2010). One study asked participants to rate their experience of simulating a specific future event on “coherence” (Anderson & Evans, 2015). Coherence was assessed by participants rating the phrase “The order of events is clear and tells a coherent story” on a Likert Scale (1 = Not at all, 7 = Extremely). A final subjective measure commonly used in studies of psychiatric populations is the Prospective Imagery Task (PIT) (MacLeod, 1996; Stöber, 2000). In this task, participants are given cues consisting of short descriptions of future scenarios and are then asked to imagine the scenario happening to them in the future. The cues have either positive or negative valence. Participants rate the vividness of the scenario on a Likert scale.

2.2. Psychiatric populations exhibit compromised episodic simulation

Objective performance. The majority of studies using objective tasks found that psychiatric populations exhibit impaired episodic simulation (Table 1). In a meta-analysis examining multiple objective measures, Halford, Austin, Takano, and Raes (2018) found that individuals with a psychiatric diagnosis had less specific and detailed episodic future thinking, and sub-group analyses suggested that there
### Table 1
Performance on selected objective measures of future simulation in psychiatric populations.

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample</th>
<th>Future Simulation Measure</th>
<th>Cue Valence</th>
<th>Scoring Method</th>
<th>Selected Findings</th>
<th>Effect size</th>
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<td>Addis et al. (2016)</td>
<td>Patients with current or past depressive symptoms versus controls</td>
<td>Modified AMT</td>
<td>Positive, negative, and neutral</td>
<td>Coded as specific, categorical, extended, or as other non-specific information</td>
<td>Depressive group &lt; controls for specific events</td>
<td>$d = -4.47$ across all cues</td>
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<tr>
<td>Anderson et al., 2015</td>
<td>Participants with dysphoria versus controls</td>
<td>Described specific near and distant future events</td>
<td>No cues</td>
<td>Coded as specific, categorical, or semantic associates</td>
<td>Participants with dysphoria &lt; controls for specific events</td>
<td>Not available</td>
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<tr>
<td>Anderson et al. (2016)</td>
<td>Participants with dysphoria versus controls</td>
<td>SCEFT</td>
<td>Cues without valence in Experiment 1</td>
<td>Coded as specific, categorical, extended, or as other non-specific information</td>
<td>Participants with dysphoria &lt; controls for specific events</td>
<td>Experiment 1: Cues without valence: $d = 0$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Positive and negative cues in Experiment 2</td>
<td>Participants with dysphoria &lt; controls for specific events in response to cues without valence</td>
<td>Participants with dysphoria &lt; controls for specific events in response to positive and negative cues</td>
<td>Negative cues: $d = -0.73$</td>
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<tr>
<td>Belcher et al., 2014</td>
<td>Patients with depression versus controls</td>
<td>Modified AMT</td>
<td>Positive and negative</td>
<td>Coded as specific, omission, or general</td>
<td>Patients with depression &lt; controls for specific events</td>
<td>$d = 0.16$ across all cues</td>
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<tr>
<td>Blix et al., 2011</td>
<td>Participants with history of trauma versus controls</td>
<td>Modified AMT</td>
<td>Positive, negative, and neutral</td>
<td>Coded as specific, categorical, extended, semantic association, or as a non-response</td>
<td>Patients with a history of trauma &lt; controls for specific events</td>
<td>No significant interaction between group and cue valence</td>
</tr>
<tr>
<td>Boelen et al. (2014)</td>
<td>Non-clinical population</td>
<td>SCEFT-2</td>
<td>Does not mention valence of cues</td>
<td>Coded as specific, extended, categorical, or semantic association</td>
<td>No significant association between specificity of future simulations and anxiety symptoms</td>
<td>$r = -0.2^*$</td>
</tr>
<tr>
<td>Boulanger et al. (2013)</td>
<td>Patients with bipolar disorder versus controls</td>
<td>Modified AMT</td>
<td>Positive and negative</td>
<td>Coded as specific, overgeneral, or a failure</td>
<td>Patients with bipolar disorder &lt; controls for specific events</td>
<td>Positive cues: $d = -1.26$</td>
</tr>
<tr>
<td>Brown et al. (2013)</td>
<td>Patients with PTSD versus controls</td>
<td>Modified AMT</td>
<td>Neutral</td>
<td>Coded as specific, intermediate, general, or no response</td>
<td>Patients with PTSD &lt; controls for specific events across recent and remote future events</td>
<td>Negative cues: $d = -0.95$</td>
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<td>Brown et al. (2014)</td>
<td>Patients with PTSD versus controls</td>
<td>Adapted AI task</td>
<td>Neutral</td>
<td>Coded into internal and external details</td>
<td>Patients with PTSD &lt; controls for internal details</td>
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<tr>
<td>Brown et al. (2016)</td>
<td>Patients with PTSD versus controls</td>
<td>Modified AMT</td>
<td>Positive and negative</td>
<td>Coded as specific, categorical, or extended</td>
<td>Patients with PTSD &lt; controls for specific events</td>
<td>Remote future events: $d = -1.84$</td>
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<tr>
<td>Chen et al. (2016)</td>
<td>Patients with schizophrenia and individuals with schizotypal personality disorder proneness versus controls</td>
<td>SCEFT</td>
<td>Does not mention valence of cues</td>
<td>Coded as specific, extended, categorical, semantic associates or omission</td>
<td>Patients with schizophrenia &lt; controls for specific events</td>
<td>$d = -0.76$</td>
</tr>
<tr>
<td>D’Argembeau et al. (2008)</td>
<td>Patients with schizophrenia versus controls</td>
<td>Modified AMT</td>
<td>Positive and Negative</td>
<td>Coded as specific, extended, categorical, or omission</td>
<td>Patients with schizophrenia &lt; controls for specific events</td>
<td>No significant interaction between group and cue valence</td>
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<tr>
<td>de Oliveira et al., 2009</td>
<td>Patients with schizophrenia versus controls</td>
<td>Described specific future events related to plans for close and distant periods</td>
<td>Does not mention valence of cues</td>
<td>Scored based on degree of specificity (from 0 = general information to 4 = detailed)</td>
<td>Patients with schizophrenia &lt; controls for specific events</td>
<td>Close periods: $d = -2.15$ across all cues</td>
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<td>Dickson et al., 2006</td>
<td>Participants with dysphoria versus controls</td>
<td>Modified AMT</td>
<td>Pleasant and unpleasant (depression and anxiety related)</td>
<td>Coded as specific, moderate, or general</td>
<td>Patients with schizophrenia &lt; controls for specific future pleasant, depressive, and anxious experiences, and findings were most notable for pleasant experiences</td>
<td>Pleasant cues: $d = -3.02$</td>
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<tr>
<td>Dickson et al. (2009)</td>
<td>Non-clinical population</td>
<td>Modified AMT</td>
<td>Negative</td>
<td>Coded as specific, extended, or categorical</td>
<td>Anxiety symptoms were not significantly correlated with specificity (past and future events combined)</td>
<td>Anxiety-related cues: $d = -1.11$</td>
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<tr>
<td>Hach et al. (2014)</td>
<td>Patients with depression versus controls</td>
<td>Modified AMT</td>
<td>Does not mention valence of cues</td>
<td>Coded as specific, categorical, extended, or non-specific information</td>
<td>Patients with depression &lt; controls for specific events</td>
<td>$d = -4.00$</td>
</tr>
</tbody>
</table>

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<tr>
<th>Study</th>
<th>Sample</th>
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<th>Cue Valence</th>
<th>Scoring Method</th>
<th>Selected Findings</th>
<th>Effect size</th>
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<tr>
<td>Hallford, Mellor, et al. (2019)</td>
<td>Non-clinical population</td>
<td>Modified AMT</td>
<td>Positive, negative, and neutral</td>
<td>Coded as specific or non-specific</td>
<td>Anxiety induction did not result in a significant change in future thinking specificity</td>
<td>Pre versus post-induction for the anxiety induction group $d = -0.12$ across all cues $d = -0.46$</td>
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<td>Hallford, Barry, et al. (2020)</td>
<td>Patients with depression versus controls</td>
<td>Variant of Modified AMT</td>
<td>Positive</td>
<td>Coded as specific or non-specific</td>
<td>Patients with depression &lt; controls for specific events</td>
<td>$d = -1.72$</td>
</tr>
<tr>
<td>Huddy et al. (2016)</td>
<td>Patients with schizophrenia or schizoaffective disorder versus controls</td>
<td>Described details of imaginary scenarios</td>
<td>Does not mention valence of cues</td>
<td>Scored on level of coherence</td>
<td>Patients with schizophrenia or schizoaffective disorder &lt; controls</td>
<td>$d = -1.05$ across all cues</td>
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<tr>
<td>King, Macdougall, Ferris, Herdman, and McKinnon (2011)</td>
<td>Patients with depression versus controls</td>
<td>Adapted AI task</td>
<td>Positive, negative, and neutral</td>
<td>Coded for internal and external details</td>
<td>Patients with depression &lt; controls for internal details No significant interaction between group and cue valence</td>
<td>$d = -0.85$</td>
</tr>
<tr>
<td>King, Williams, et al. (2011)</td>
<td>Patients with bipolar disorder versus controls</td>
<td>Adapted AI task</td>
<td>Positive, negative, and neutral</td>
<td>Coded for internal and external details</td>
<td>Patients with bipolar disorder &lt; controls for internal details No significant interaction between group and cue valence</td>
<td>$d = -0.46$</td>
</tr>
<tr>
<td>Klein et al. (2014)</td>
<td>Patients with PTSD versus controls</td>
<td>Modified AMT</td>
<td>Positive and negative</td>
<td>Coded as specific or non-specific</td>
<td>Patients with PTSD &lt; controls for specific events in response to positive cues; Patients with PTSD − controls for specific events in response to negative cues</td>
<td>Positive cues: $d = 0.57^<em>$ Negative cues: $d = 0.28^</em>$</td>
</tr>
<tr>
<td>Marsh et al. (2018)</td>
<td>Non-clinical population</td>
<td>Described specific future events</td>
<td>Neutral</td>
<td>Coded as specific or non-specific</td>
<td>Anxiety was significantly correlated with the number of specific future events produced</td>
<td>$r = -0.197^*$</td>
</tr>
<tr>
<td>Malek et al. (2019)</td>
<td>Patients with schizophrenia versus controls</td>
<td>Described specific future events</td>
<td>Does not mention valence of cues</td>
<td>Coded for contextual details</td>
<td>Patients with schizophrenia &lt; controls</td>
<td>Not available</td>
</tr>
<tr>
<td>Painter et al., 2016</td>
<td>Patients with schizophrenia or schizoaffective disorder versus controls</td>
<td>Described specific future events</td>
<td>Positive, negative, and neutral</td>
<td>Coded for time/place details and clarity</td>
<td>Patients with schizophrenia or schizoaffective disorder &lt; controls for time/place details across all cues Patients with schizophrenia or schizoaffective disorder &lt; controls for clarity in response to negative cues only</td>
<td>Completed memory task before prospection Time/place details Positive: $d = -0.51$ Negative: $d = -0.17$ Neutral: $d = -0.48$ Clarity Positive: $d = -0.30$ Negative: $d = -0.48$ Neutral: $d = 0$ Completed control task before prospection Time/place details Positive: $d = -0.41$ Negative: $d = 0.09$ Neutral: $d = -0.20$ Clarity Positive: $d = -0.29$ Negative: $d = -0.64$ Neutral: $d = -0.18$ Positive cues: $d = -0.40$ Negative cues: $d = -0.26$ Neutral cues: $d = -0.45$</td>
</tr>
<tr>
<td>Parlar et al. (2016)</td>
<td>Trauma-exposed patients with depression versus controls</td>
<td>Adapted AI task</td>
<td>Positive, negative, neutral</td>
<td>Coded for internal and external details</td>
<td>Patients with depression &lt; controls for internal details in response to neutral cues (trending effect) Patients with depression − controls for internal details in response to positive and negative cues</td>
<td>Sensory descriptions: $d = -0.85$ Spatial references: $d = -0.59$ Quality judgment: $d = -0.80$</td>
</tr>
<tr>
<td>Raffard et al. (2010)</td>
<td>Patients with schizophrenia versus controls</td>
<td>Scene construction and future simulation task (Hassabis et al., 2007)</td>
<td>Does not mention valence of cues</td>
<td>Coded for sensory descriptions, spatial references, and quality judgment</td>
<td>Patients with schizophrenia &lt; controls across all selected outcomes</td>
<td>$d = -0.80$</td>
</tr>
<tr>
<td>Raffard et al. (2013)</td>
<td>Patients with schizophrenia versus controls</td>
<td>Adaptation of scene construction and future simulation task (Hassabis et al., 2007)</td>
<td>Positive and negative</td>
<td>Coded as specific, categorical, or extended</td>
<td>Patients with schizophrenia &lt; controls for specific events, most notably in response to positive cues</td>
<td>Positive cues: $d = -1.15$ Negative cues: $d = -0.73$</td>
</tr>
<tr>
<td>Raffard et al. (2016)</td>
<td>Patients with schizophrenia versus controls</td>
<td>Described self-defining future events</td>
<td>None</td>
<td>Coded as specific or non-specific</td>
<td>Patients with schizophrenia &lt; controls for specific events</td>
<td>$d = 0.05$</td>
</tr>
</tbody>
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were significant effects for depression, bipolar disorder, and schizophrenia. In another meta-analysis, Gamble, Moreau, Tippett, and Addis (2019) observed that higher levels of depression were associated with reduced future specificity (including both subjective and objective measures) across patients with depression and non-clinical participants. The relationship between depression and future specificity did not differ as a function of type of future thinking (imagination, intention, or planning) (Gamble et al., 2019, p. 825). Findings from studies using measures of episodic simulation in psychiatric populations will be discussed.

Using tasks that assessed the specificity of future simulations (modified AMT task, SCEFT, or slightly modified tasks), patients with depression (Addis et al., 2016; Belcher & Kangas, 2014; Hach, Tippett, & Addis, 2014; Hallford, Barry, et al., 2020), suicidality (most of whom had a depression diagnosis) (Williams et al., 1996), dysphoria (see Footnote) (Anderson, Boland, & Garner, 2016; Dickson & Bates, 2006), PTSD (Brown et al., 2013; Kleim, Graham, Filhosy, Stott, & Ehlers, 2014), schizophrenia (Chen et al., 2016; D’Argembeau, Raffard, & Van der Linden, 2008; de Oliveira et al., 2009; Raffard, Esposito, Boulenger, & Van der Linden, 2013; Wang et al., 2017), and bipolar disorder (Boulanger, Lejeune, & Blair, 2013) described future simulations with less specificity when compared to controls. Patients with schizophrenia (Yang et al., 2019) provided future simulations with fewer internal details (i.e., details tied to a specific time and place) than controls.

Using similar measures to the adapted AI task, patients with schizophrenia have been observed to include less time and place details (Painter & Kring, 2016) and contextual details (Malek et al., 2019) when describing the future. Patients with schizophrenia have also communicated future simulations with less coherence (Huddy et al., 2016) and clarity (Painter & Kring, 2016) than controls. Yang et al. (2018) found that patients with social anhedonia (according to self-report measures in a non-clinical population) and schizophrenia provided less rich future simulations. Raffard, D’Argembeau, Bayard, Boulenger, and Van der Linden (2010) observed that patients with schizophrenia provided future simulations with fewer sensory descriptions, fewer spatial references, and poorer quality than controls while using the scene construction task. Based on these studies and multiple meta-analyses, there is notable evidence for impaired future simulation in patients with psychiatric conditions or individuals with elevated psychiatric symptoms when using objective tasks.

A small selection of studies using the modified AMT or a similar task found no impairments in providing specific future simulations in individuals with dysphoria (Anderson & Evans, 2015), PTSD (Brown et al., 2016), schizophrenia (Raffard et al., 2016) and individuals with a trauma history (without a clinical diagnosis) (Blix & Brennen, 2011). Differences in methodology may have contributed to these findings. Anderson and Evans (2015) did not include emotionally valenced cues, which were included in the other studies that examined individuals with dysphoria (Anderson et al., 2016; Dickson & Bates, 2006). Brown et al. (2016) had participants recall autobiographical memories before simulating specific events. This methodology may have allowed participants to practice providing specific details, potentially resulting in intact future simulation in patients with PTSD. Raffard et al. (2016) instructed participants to generate a future event that is related to their sense of self, is related to an “important and enduring theme, issue, conflict, or

Table 1 (continued)

<table>
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<tr>
<th>Study</th>
<th>Sample</th>
<th>Future Simulation Measure</th>
<th>Cue Valence</th>
<th>Scoring Method</th>
<th>Selected Findings</th>
<th>Effect size</th>
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<td>Wang et al. (2017)</td>
<td>Patients with schizophrenia versus controls</td>
<td>Modified AMT</td>
<td>Positive, negative, neutral</td>
<td>Coded as specific or non-specific</td>
<td>Patients with schizophrenia controls for specific events</td>
<td>d = –0.65 across all cues</td>
</tr>
<tr>
<td>Williams et al. (1996)</td>
<td>Patients with suicidality (most of whom had a depression diagnosis)</td>
<td>Modified AMT</td>
<td>Positive, negative, neutral</td>
<td>Coded as specific, intermediate, or general</td>
<td>Patients with suicidality controls for specific events</td>
<td>Positive cues: d = –0.35 Negative cues: d = –0.31 Neutral cues: d = –0.71</td>
</tr>
<tr>
<td>Yang et al. (2018)</td>
<td>Patients with schizophrenia versus controls</td>
<td>Described specific future events</td>
<td>Positive, negative, and neutral</td>
<td>Richness of thought/emotion details</td>
<td>Patients with schizophrenia controls for richness of thought/emotion details</td>
<td>Positive cues: d = –0.57 Negative cues: d = –0.41 Neutral cues: d = –0.34 Social anhedonia findings:</td>
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<tr>
<td>Yang et al. (2019)</td>
<td>Patients with schizophrenia versus controls</td>
<td>Adapted AI task</td>
<td>Positive, negative, and neutral</td>
<td>Coded as internal and external details</td>
<td>Patients with schizophrenia controls for internal details</td>
<td>d = –0.72 across all cues</td>
</tr>
</tbody>
</table>

Note. Adapted AI task = Adapted Autobiographical Interview. Modified AMT = modified Autobiographical Memory Test. SCEFT = Sentence Completion for Events in the Future Test. “Not available” indicates that information was not provided to calculate effect size(s). Cohen’s d effect sizes were calculated using means and pooled standard deviations. The following formula was used: d = (M1-M2)/SD pooled. *A few studies did not provide the relevant summary statistics, and as a result the effect size was obtained from the published manuscripts if they were available.

Footnote: Studies that included participants with dysphoria were categorized into dysphoric and non-dysphoric groups based on a self-report measure of depression.
concern from one’s life,” generates strong feelings, and is an event they have thought about many times. Generating this type of future event may have allowed them to successfully engage in episodic simulation. Lastly, Blix and Brennen (2011) noted having methodological differences compared to other studies in PTSD, such as cueing participants to retrieve a specific future event on each trial. Blix and Brennen (2011) also examined patients with a trauma history, rather than patients with a diagnosis of PTSD. Although a few studies produced alternative findings, the majority of studies found that future simulation is impaired across multiple psychiatric populations when using objective measures of future simulation.

Finally, a number of studies have examined the relationship between the specificity of episodic simulations and anxiety in non-clinical populations (Boelen, Hunjens, & van den Hout, 2014; Dickson, Moberly, Hammon, & Bates, 2009; Marsh, Edginton, Conway, & Loveday, 2018). Findings are mixed across studies. Boelen et al. (2014) and Dickson et al. (2009) did not find a significant correlation between the specificity of future episodic simulations and anxiety symptoms in non-clinical participants. Halford et al. (2019) examined a non-clinical population and found that an anxiety induction did not result in a significant change in future thinking specificity as assessed by the modified AMT. However, the authors noted that the level of anxiety produced by their induction might not have been high enough to impact future simulation. Alternatively, Marsh et al. (2018) investigated the simulation of specific events in a non-clinical adult population and there was a significant correlation between the specificity of future simulations and anxiety symptoms. Overall, there are mixed findings regarding the relationship between anxiety and future simulation in non-clinical populations. Mixed findings may be due to differences in the severity of anxiety symptoms between studies, but it is difficult to determine based on how anxiety levels were reported.

Valence effects using objective measures. Some studies have examined whether cue valence impacts objective episodic simulation performance in psychiatric populations. The impact of cue valence was first investigated in autobiographical memory research. Previous autobiographical memory studies used positive and negative cues to elicit autobiographical memories and they observed that patients with history of suicide attempt provided less specific autobiographical memories (Williams & Broadbent, 1986; Williams & Dritschel, 1988; Williams et al., 1996). The exploration of autobiographical memories elicited by emotionally valenced words was motivated by research that found congruence between mood and the valence of retrieved memories (Blaney, 1986; Ien, 1984, pp. 179–236). The findings in autobiographical memory research led to the examination of emotionally valenced cues and future simulation. Studies have investigated whether cue valence impacts future simulation performance differently in patients with psychiatric conditions when compared to controls. Overall, there is no clear pattern of findings, as some objective studies found that cue valence impacted episodic simulation performance in psychiatric populations when compared to controls (Gamble et al., 2019; Kleim et al., 2014; Painter & Kring, 2016; Parlar et al., 2016; Raffard et al., 2013) and others found no association (Boulanger et al., 2013; D’Argembeau et al., 2008; King, Mac dougall, et al., 2011; King, Williams, et al., 2011; Wang et al., 2017; Williams et al., 1996; Yang et al., 2018). Findings were also variable in participants without a psychiatric diagnosis. Specifically, Anderson et al. (2016) and Dickson and Bates (2006) found cue valence impacted episodic simulation performance in individuals with schizophrenia, whereas Blix and Brennen (2011) and Yang et al. (2018) found no association in individuals with a trauma history and individuals with social anhedonia respectively. In light of these findings, definitive conclusions cannot be drawn regarding the impact of cue valence on objective episodic simulation performance in psychiatric populations.

Subjective experience during episodic simulation. Studies show that subjective experience during episodic simulation is frequently altered in psychiatric populations (Table 2). The PIT is a measure most frequently used to examine subjective experience during episodic simulation in psychiatric populations. Using the PIT, participants are presented with positively and negatively valenced future scenarios, and then they are asked to rate the vividness of the imagined scenario (described above) (MacLeod, 1996; Stöber, 2000). In depression (Morina et al., 2011), dysthymia (Boland et al., 2018; Holmes, Lang, Moulds, & Steele, 2008), and anxiety (Morina et al., 2011), patients rated positive future events as having lower vividness when compared to controls. In dysthymia (Boland et al., 2018; Holmes et al., 2008), anxiety (Morina et al., 2011; Raune, MacLeod, & Holmes, 2005), and bipolar disorder (Di Simplicio et al., 2016; Holmes et al., 2011), patients rated negative future events as having higher vividness when compared to controls. Non-clinical individuals who reported higher levels of visual hallucination experiences rated negative future events as having higher imagery (i.e., higher ratings of vividness and experiencing) when compared to those with lower reported levels of visual hallucination experiences (Aynsworth, Nemati, Collerton, Smailles, & Dudely, 2017). Overall, studies using the PIT found altered subjective experience during episodic simulation in psychiatric populations. They also found that subjective experience may be moderated by cue valence, such that patients report that they more vividly experience future negative events and/or less vividly experience future positive events.

Studies using other subjective measures reported variable findings, including either diminished or enhanced subjective experience during episodic simulation. When simulating the future, patients with schizophrenia reported less subjective experience on the following indices compared to controls: sensory details (Painter & Kring, 2016; Raffard et al., 2013); contextual information, self-referential information, and other-referential information, (Raffard et al., 2013); vividness and sense of pre-experiencing (Yang et al., 2018); and sense of mental time travel (Malek et al., 2019). Raffard et al. (2010) observed that patients with schizophrenia rated their perceived sense of presence, salience, and spatial coherence lower when compared to controls across both atemporal and future scenarios using the scene construction task. In a study by Yang et al. (2018), individuals with social anhedonia rated future simulations as having less sense of pre-experiencing. Individuals with dysphoria (Anderson & Evans, 2015) and patients with depression (Halford, Barry, et al., 2020) rated future simulations as having lower vividness than controls, as well as lower on other aspects of subjective experience. Wu et al. (2015) instructed individuals with generalized anxiety disorder (GAD) and controls to simulate specific future events and then they repeated the simulation of future events. Wu et al. (2015) found that patients with GAD initially did not differ from controls when rating the amount of detail in their future simulations. However, when repeating these future simulations, individuals with GAD did not spontaneously rate simulations as increasingly detailed as seen in controls. Similar to findings using the PIT, Winfield and Ramboj (2010) observed that non-clinical individuals with higher levels of schizotypy rated their future simulation as having higher olfactory detail and a greater feeling of mental time travel. Gehrt, Frostholm, Obermann, and Berntsen (2019) found that individuals with severe health anxiety and obsessive-compulsive disorder rated future every day and anxiety-related events higher in various qualities, including mental time travel, vividness, and emotional intensity when compared to controls. Overall, these studies further support altered subjective experience during future simulation in psychiatric populations.

Some studies did not find compromised episodic simulation performance using subjective measures. de Oliveira et al. (2009) asked patients with schizophrenia and controls to rate their ability to pre-experience specific future plans after describing them, and subjective ratings did not differ between groups. Raffard et al. (2016) asked participants to simulate self-defining future events and found that patients with schizophrenia rated their subjective experience as lower on other-referential information, but similar to controls across other subjective indices, including sensory details, contextual information, self-referential information, coherence, and perspective. de Oliveira et al. (2009) also found that patients with psychotic disorders (i.e., higher ratings of vividness and experiencing) when compared to those with lower reported levels of visual hallucination experiences (Aynsworth, Nemati, Collerton, Smailles, & Dudley, 2017). Overall, studies using the PIT found altered subjective experience during episodic simulation in psychiatric populations. They also found that subjective experience may be moderated by cue valence, such that patients report that they more vividly experience future negative events and/or less vividly experience future positive events.
## Table 2
Performance on selected subjective measures of future simulation in psychiatric populations.

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample</th>
<th>Future Simulation Measure</th>
<th>Cue Valence</th>
<th>Selected Participant Ratings</th>
<th>Selected Findings</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Addis et al. (2016)</td>
<td>Patients with current or past depressive symptoms versus controls</td>
<td>Modified AMT</td>
<td>Positive, negative, and neutral</td>
<td>Detail Emotional intensity</td>
<td>Patients with depression = controls across selected ratings Did not analyze interaction between group and cue valence</td>
<td>Detail: $d = -1.33$ across all cues Emotional intensity: $d = -0.57$ across all cues</td>
</tr>
<tr>
<td>Anderson et al., 2015</td>
<td>Participants with dysphoria versus controls</td>
<td>Described specific near and distant future events</td>
<td>No cues</td>
<td>Vividness</td>
<td>Participants with dysphoria $&lt;$ controls for near and distant future events</td>
<td>Near future: $d = -0.64$ Distant future: $d = -1.03$</td>
</tr>
<tr>
<td>Aynsworth et al. (2017)</td>
<td>Non-clinical individuals with higher predisposition to visual hallucinations versus lower predisposition to visual hallucinations</td>
<td>PIT</td>
<td>Positive and negative</td>
<td>Vividness Experiencing</td>
<td>Participants with higher visual hallucination experiences $&lt;$ lower visual hallucination experiences for positive cues across selected ratings Participants with higher visual hallucination experiences $&gt;$ lower visual hallucination experiences for negative cues across selected ratings</td>
<td>Positive cues: Vividness: $d = 0.02$ Experiencing: $d = 0.09$ Negative cues: Vividness: $d = 0.61$ Experiencing: $d = 0.59$</td>
</tr>
<tr>
<td>Boland et al. (2018)</td>
<td>Participants with dysphoria versus controls</td>
<td>Simulated future events before and after a simulation intervention (Experiment 2)</td>
<td>Positive and Negative</td>
<td>Vividness</td>
<td>Participants with high dysphoria $&lt;$ controls for positive cues Participants with high dysphoria $&gt;$ controls for negative cues</td>
<td>Pre-simulation: Positive: $d = -0.93$ Negative: $d = 1.56$ Post-simulation: Positive: $d = -0.64$ Negative: $d = 1.03$</td>
</tr>
<tr>
<td>de Oliveira et al., 2009</td>
<td>Patients with schizophrenia versus controls</td>
<td>Described specific future events related to plans for close and distant periods</td>
<td>Does not mention valence of cues</td>
<td>Ability to pre-experience (“picture”) what, where, and when information</td>
<td>Participants with schizophrenia $=$ controls</td>
<td></td>
</tr>
<tr>
<td>Di Simplicio et al. (2016)</td>
<td>Participants with bipolar disorder versus controls</td>
<td>PIT</td>
<td>Positive and negative</td>
<td>Vividness</td>
<td>Participants with bipolar disorder $=$ controls for positive cues Participants with bipolar disorder $&gt;$ controls for negative cues</td>
<td></td>
</tr>
<tr>
<td>Finnbogadottir et al., 2014</td>
<td>Non-clinical high worriers versus low worriers</td>
<td>Described future events</td>
<td>Word-cued, afraid, happy, ashamed, proud, and important</td>
<td>Specificity Vividness Perspective (from “my own eyes” to an observer’s eyes)</td>
<td>High worriers $&gt;$ low worriers for observer perspective; High worriers $=$ low worriers for specificity and vividness No significant interaction between group and cueing</td>
<td></td>
</tr>
<tr>
<td>Gehrt et al. (2019)</td>
<td>Individuals with severe health anxiety versus controls Patients with OCD versus controls</td>
<td>Described specific future events</td>
<td>Everyday events and anxiety-related events</td>
<td>Mental time travel Vividness Emotional intensity</td>
<td>Mental time travel: Clinical groups (severe health anxiety and OCD) $&gt;$ controls Vividness and emotional intensity: Clinical groups (severe health anxiety and OCD) $&gt;$ controls; difference more pronounced when future event was anxiety-related</td>
<td>Severe health anxiety findings: Mental time travel Everyday events: $d = 0.77$ Anxiety events: $d = 1.05$ Vividness Everyday events: $d = 0.73$ Anxiety events: $d = 1.33$ Emotional intensity Everyday events: $d = 0.62$ Anxiety events: $d = 0.93$ OCD findings: Mental time travel Everyday events: $d = 0.45$ Anxiety events: $d = 1.04$ Vividness Everyday events: $d = 0.83$ Anxiety events: $d = 0.51$</td>
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</tbody>
</table>

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<table>
<thead>
<tr>
<th>Study</th>
<th>Sample</th>
<th>Future Simulation Measure</th>
<th>Cue Valence</th>
<th>Selected Participant Ratings</th>
<th>Selected Findings</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hach et al. (2014)</td>
<td>Patients with depression versus controls</td>
<td>Modified AMT</td>
<td>Does not mention valence of cues</td>
<td>Detail/Vividness</td>
<td>Patients with depression &lt; controls across selected ratings</td>
<td>1.41</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Positive</td>
<td>Emotional intensity</td>
<td></td>
<td></td>
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<tr>
<td>Hallford, Barry, et al. (2020)</td>
<td>Patients with depression versus controls</td>
<td>Variant of Modified AMT</td>
<td>Positive and negative</td>
<td>Vividness</td>
<td>Patients with depression &lt; controls</td>
<td>–0.77</td>
</tr>
<tr>
<td>Holmes et al. (2008)</td>
<td>Participants with dysphoria versus controls</td>
<td>PIT</td>
<td>Positive and negative</td>
<td>Vividness</td>
<td>Patients with dysphoria &lt; controls for positive cues</td>
<td>–0.63</td>
</tr>
<tr>
<td>Holmes et al. (2011)</td>
<td>Participants with bipolar disorder versus controls</td>
<td>PIT</td>
<td>Positive and negative</td>
<td>Vividness</td>
<td>Patients with bipolar disorder &lt; controls for positive cues</td>
<td>0.53</td>
</tr>
<tr>
<td>Malek et al. (2019)</td>
<td>Patients with schizophrenia versus controls</td>
<td>Described specific future events</td>
<td>Does not mention valence of cues</td>
<td>Sense of Mental Time Travel</td>
<td>Patients with schizophrenia &lt; controls</td>
<td>0.87</td>
</tr>
<tr>
<td>Morina et al. (2011)</td>
<td>Participants with depression versus controls</td>
<td>PIT</td>
<td>Positive and negative</td>
<td>Vividness</td>
<td>Patients with depression &lt; controls for positive cues, Patients with anxiety &lt; controls for negative cues</td>
<td>–0.40</td>
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<tr>
<td></td>
<td>Participants with anxiety disorders versus controls</td>
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<td>Patients with anxiety &gt; controls for negative cues</td>
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<tr>
<td>Painter et al., 2016</td>
<td>Patients with schizophrenia or schizoaffective disorder versus controls</td>
<td>Described specific future events</td>
<td>Positive, negative, and neutral</td>
<td>Sensory experience</td>
<td>Patients with schizophrenia or schizoaffective disorder &lt; controls</td>
<td>–0.29</td>
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<td></td>
<td>No interaction between group and cue valence</td>
<td>–0.38</td>
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<tr>
<td>Raffard et al. (2010)</td>
<td>Patients with schizophrenia versus controls</td>
<td>Scene construction and future simulation task (Hassabis et al., 2007)</td>
<td>Does not mention valence of cues</td>
<td>Sense of presence</td>
<td>Patients with schizophrenia &lt; controls across atemporal and future scenarios for all selected ratings</td>
<td>–0.74</td>
</tr>
<tr>
<td></td>
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<td>Perceived salience</td>
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<td>Spatial coherence</td>
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<tr>
<td>Raffard et al. (2013)</td>
<td>Patients with schizophrenia versus controls</td>
<td>Adaptation of scene construction and future simulation task (Hassabis et al., 2007)</td>
<td>Positive and negative</td>
<td>Sensory details</td>
<td>Patients with schizophrenia &lt; controls across selected ratings</td>
<td>–1.35</td>
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<td>Contextual information</td>
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<td>Self-referential information</td>
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<td>Other referential information</td>
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Table 2 (continued)

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample</th>
<th>Measure</th>
<th>Future Simulation</th>
<th>Cue Valence</th>
<th>Selected Participant Ratings</th>
<th>Selected Findings</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raffard et al. (2016)</td>
<td>Patients with schizophrenia versus controls</td>
<td>Described self-defining future events</td>
<td>None</td>
<td>Sensory details, Contextual information, Self-referential information, Other-referential information, Coherence, Perspective</td>
<td>Participants with schizophrenia &lt; other-referential information, Participants with schizophrenia = controls on all other ratings</td>
<td>Sensory details: d = −0.20 Contextual: d = −0.21 Self-referential: d = −0.26 Other-referential: d = −0.61 Coherence: d = −0.26 Perspective: d = −0.08</td>
<td></td>
</tr>
<tr>
<td>Raune et al. (2005)</td>
<td>Participants with anxiety versus controls</td>
<td>Described future events</td>
<td>Positive</td>
<td>Vividness</td>
<td>Participants with anxiety &gt; controls</td>
<td>Olfactory detail: d = 0.57 Mental time travel: d = 1.07 First simulation: Positive Cues: d = 0.24 Negative Cues: d = 0.48 Neutral Cues: d = 0.17 Fourth simulation: Positive Cues: −0.26 Negative Cues: −0.25 Neutral Cues: −0.38</td>
<td></td>
</tr>
<tr>
<td>Winfield et al., 2010</td>
<td>Non-clinical participants with higher levels of schizotypy versus lower levels of schizotypy</td>
<td>Imagined specific future events</td>
<td>Negative</td>
<td>Olfactory detail, Subjective time travel, Detail</td>
<td>Individuals with higher levels of schizotypy &gt; lower levels of schizotypy for olfactory detail and subjective time travel Patients with GAD = controls initially; When simulations were repeated, patients with GAD did not rate simulations as increasingly detailed as seen in controls No interaction between group and cue valence</td>
<td>Olfactory detail: d = 0.57 Mental time travel: d = 1.07 First simulation: Positive Cues: d = 0.24 Negative Cues: d = 0.48 Neutral Cues: d = 0.17 Fourth simulation: Positive Cues: −0.26 Negative Cues: −0.25 Neutral Cues: −0.38</td>
<td></td>
</tr>
<tr>
<td>Wu et al. (2015)</td>
<td>Patients with generalized anxiety disorder versus controls</td>
<td>Simulated specific future events</td>
<td>Positive, negative, and neutral</td>
<td>Sensory details, Contextual information, Self-referential information, Other-referential information, Coherence, Perspective</td>
<td>Patients with anxiety &lt; controls, Patients with schizophrenia &lt; controls for vividness and sense of pre-experiencing Individuals with social anhedonia &lt; controls for sense of pre-experiencing; Individuals with social anhedonia = controls for vividness No significant interaction between group and cue valence</td>
<td>Sensory details: d = 0.78 Vividness: d = 0.46 Contextual: d = 0.29 Self-referential: d = 0.65 Other-referential: d = 0.63 Social anhedonia: d = 0.63</td>
<td></td>
</tr>
<tr>
<td>Yang et al. (2018)</td>
<td>Patients with schizophrenia versus controls Individuals with social anhedonia versus controls</td>
<td>Described specific future events</td>
<td>Positive, negative, and neutral</td>
<td>Sensory details, Contextual information, Self-referential information, Other-referential information, Coherence, Perspective</td>
<td>Participants with schizophrenia &lt; controls for vividness and sense of pre-experiencing Individuals with social anhedonia &lt; controls for sense of pre-experiencing; Individuals with social anhedonia = controls for vividness No significant interaction between group and cue valence</td>
<td>Sensory details: d = 0.78 Vividness: d = 0.46 Contextual: d = 0.29 Self-referential: d = 0.65 Other-referential: d = 0.63 Social anhedonia: d = 0.63</td>
<td></td>
</tr>
</tbody>
</table>

Note. Adapted AI task = Adapted Autobiographical Interview. Modified AMT = modified Autobiographical Memory Test. PFT = Prospective Imagery Task. SCEFT = Sentence Completion for Events in the Future Test. “Not available” indicates that information was not provided to calculate effect size(s). Cohen’s d effect sizes were calculated using means and pooled standard deviations. The following formula was used: \( d = (M_1 - M_2)/SD \) pooled.

et al. (2009) and Raffard et al. (2016) may have had different findings regarding subjective experience than other studies in schizophrenia due to methodological differences, such as asking participants to simulate future plans or self-defining future events, respectively. Finnbogadóttir and Berntsen (2014) found that non-clinical high worriers rated their perspective when simulating future events as more “observer-like” when compared to low worriers, but did not differ on other subjective ratings, such as specificity and vividness. These findings differed from Wu et al. (2015) in their study of patients with GAD, as patients with GAD demonstrated smaller increases in ratings of detail after repeating future simulations when compared to controls. It is possible that Finnbogadóttir and Berntsen (2014) would have found differences on specificity and vividness ratings if participants repeated their simulations of the future. Finnbogadóttir and Berntsen (2014) also examined worry in a non-clinical population, whereas Wu et al. (2015) examined individuals diagnosed with GAD. A few studies did not find subjective differences between patients with depression and controls. Addis et al. (2016) and Hach et al. (2014) observed that patients with depression subjectively rated the level of detail and emotional intensity similarly to controls when simulating the future. It is unclear why Addis...
et al. (2016) and Hach et al. (2014) reported different findings compared to other studies with subjective ratings in individuals with dysphoria (Anderson & Evans, 2015; Boland et al., 2018; Holmes et al., 2008) and depression (Morina et al., 2011). While there is some variability in the literature, most studies found that subjective experience was compromised during future simulation in psychiatric populations.

Valence effects using subjective measures. As described earlier, studies using the PIT or a similar task in patients with depression (Morina et al., 2011), dysphoria (Boland et al., 2018; Holmes et al., 2008), anxiety (Morina et al., 2011), bipolar disorder (Di Simplicio et al., 2016; Holmes et al., 2011), and non-clinical individuals with a higher predisposition to visual hallucinations (Aynsworth et al., 2017) found that the valence of future scenarios impacted ratings of their subjective experience when compared to controls. Most other studies using alternative subjective measures did not find that cue valence impacted subjective experience during episodic simulation in patients with schizophrenia (Painter & Kring, 2016; Raffard et al., 2013; Yang et al., 2018) and GAD (Wu et al., 2015) when compared to controls. However, findings by Gehrt et al. (2019) suggest that the difference in valence ratings (such as vividness and emotional intensity) between the clinical groups (severe health anxiety and OCD) and controls is more pronounced when the future event was anxiety-related. Though findings are variable, valence may moderate subjective experience in psychiatric populations.

Summary. Episodic simulation is altered in a range of psychiatric populations. Studies using objective measures suggest that participants with psychiatric conditions and elevated psychiatric symptoms provide fewer internal details or specific details during episodic simulation, including patients with depression, dysphoria, suicidality, PTSD, schizophrenia, and bipolar disorder, as well as individuals with social anhedonia. Some research suggests that subjective experience during episodic simulation is also altered in psychiatric populations and individuals with elevated psychiatric symptoms, including patients with depression, dysphoria, schizophrenia, bipolar disorder, OCD, anxiety, individuals with higher reported levels of visual hallucination experiences, individuals with higher levels of schizotypy, and individuals with social anhedonia. These psychiatric populations rate their subjective experience during episodic simulation as either diminished or increased during episodic simulation, which may also be moderated by cue valence. However, there are some studies finding intact subjective experience in psychiatric populations.

Given evidence for impaired or altered episodic simulation in psychiatric populations, it is important to explore the factors that may contribute to episodic simulation performance in these groups. There are various cognitive mechanisms that may contribute to episodic simulation impairment in psychiatric conditions, including episodic memory, scene construction, mental imagery, components of the GaR-FAX model (Williams, 2006; Williams et al., 2007) (i.e., functional avoidance, rumination, and executive functioning), and narrative style.

3. Cognitive mechanisms of compromised episodic simulation in psychiatric populations

3.1. Episodic memory retrieval

Substantial evidence suggests that episodic memory, specifically episodic retrieval, is closely related to the ability to simulate the future (Schacter & Addis, 2007; 2020), pp. 111–131; Schacter, Addis, & Bucker, 2007). Evidence supporting the role of the episodic retrieval in future simulation includes the overlap in cognitive and neural processes that have been documented when people remember the past and imagine the future (Schacter, 2019; Schacter et al., 2008, 2012). Specifically, past and future thinking share a core neural network and phenomenological characteristics, and patients with neurological and psychiatric conditions have impairments across past and future thinking (Addis & Schacter, 2012; Benoit & Schacter, 2015). Based on these and other findings, Schacter and Addis proposed the constructive episodic simulation hypothesis (Schacter & Addis, 2007, 2020, pp. 111–131; Schacter et al., 2007). This hypothesis states that past and future thinking rely on the episodic memory retrieval, which enables the ability to simulate the future by supporting flexible recombination of details from different past experiences into simulations of a novel future event. Because the future is rarely identical to the past, flexible recombination is viewed as an adaptive process, but the same flexible retrieval process can also lead to memory errors when elements of past experiences are misconstrued (for relevant evidence, see Carpenter & Schacter, 2017, 2018).

Researchers have increasingly investigated the relationship between episodic memory and episodic simulation in psychiatric populations. Much of this work suggests that episodic memory may be a mechanism contributing to future simulation impairment in certain psychiatric populations. Specifically, individuals with psychiatric conditions may have deficits in retrieving and/or recombining episodic details when remembering the past and simulating the future. Studies in psychiatric populations have found a positive relationship between episodic memory (i.e., retrieval of a specific autobiographical memory) and future simulation. Using the AMT, moderate to large positive correlations were observed between specificity of autobiographical remembering and future simulation in patients with depression (Addis et al., 2016; Belcher & Kangas, 2014), patients with history of suicide attempt (Williams et al., 1996), PTSD (Brown et al., 2013), and schizophrenia (D’Argembeau et al., 2008). These studies used neutral cues (Brown et al., 2013) or found significant positive correlations across all cues regardless of valence (Addis et al., 2016; Belcher & Kangas, 2014; D’Argembeau et al., 2008; Williams et al., 1996). Using the adapted AI task with neutral cues, significant positive correlations were found between internal details (i.e., episodic details tied to a specific time and place) when remembering past events and simulating future events in patients with depression (r = 0.68, p < .001) (McFarland, Primosch, Maxson, & Stewart, 2017) and PTSD (r = 0.80, p = .001) (Brown et al., 2014). Chen et al. (2016) asked participants to remember autobiographical events (Sentence Completion for Events in the Past; SCEPT) and simulate possible future events (SCEPT). Chen et al. (2016) found a moderate positive correlation (r = 0.42, p < .001) between the specificity of remembering past events and simulating future events across patients with schizophrenia and controls.

A few studies produced alternative findings when examining the relationship between autobiographical memory and future simulation. Blix and Brennen (2011) examined the correlation between specificity of the episodic remembering and future simulation using the AMT across participants with a trauma history (without a clinical diagnosis) and controls, and found that the relationship depended on cue valence. Specifically, there was a positive relationship between specificity of autobiographical remembering and future simulation for positive cue words (r = .42, p < .01), a negative correlation for neutral cue words (r = −.31, p < .05), and no significant correlation for negative cue words (r = 0.03, p = .83). Blix and Brennen (2011) noted that their findings (i.e., negative correlation for neutral cue words and a lack of a significant correlation for negative cue words) differed from other studies that found a positive relationship between autobiographical remembering and future simulation (e.g., D’Argembeau et al., 2008; Williams et al., 1996). Blix and Brennen (2011) stated that their findings may be due to methodological differences, such as their task being in a computerized format rather than an interview format, providing reminders to retrieve a specific event with each cue word, and using different cue words in their study. One study in bipolar patients required patients to retrieve specific past and future autobiographical events using the AMT and found that specificity of autobiographical remembering and future simulation was not significantly correlated (r = 0.19, p = .43) (Boulanger et al., 2013). There is no evidence thus far examining the relationship between autobiographical remembering and future episodic simulation in anxiety disorders. Overall, most research in
psychiatric populations suggests that there is a positive association be-
tween remembering the past and imagining the future.

The role of episodic memory in future simulation has also been
supported through studies that experimentally manipulate the retrieval
of episodic details using an episodic specificity induction (ESI; for review,
see Schacter & Madore, 2016), which involves brief training in recalling
episodic details of a recent event. The ESI boosted performance on
subsequent tasks that required healthy young and older adults to
remember past experiences and imagine future experiences by
increasing internal (i.e., episodic) details, while having no effect on
external (i.e., semantic) details (Madore, Gaesser, & Schacter, 2014).
This enhancement was selective: ESI had no effect in young or old adults
on a picture description task that does not draw on episodic retrieval.

The ESI has also improved participant performance on other tasks that
recruit episodic retrieval, including social problem-solving (Jing et al.,
2016; Madore & Schacter, 2014) and divergent creative thinking in both
young and old adults (Madore, Addis, & Schacter, 2015; Madore, Jing, &
Schacter, 2016). These studies support the role of episodic retrieval in
future imagining, as well as other cognitive processes that rely on
episodic retrieval.

One study using the ESI supports episodic retrieval as a cognitive
mechanism contributing to future simulation in depression. McFarland
et al. (2017) found that the ESI resulted in increased generation of internal
details during the simulation of future events in individuals with
depression. The ESI also enhanced performance on memory and
problem-solving tasks, which are also tasks that rely on episodic retrieval.
This study supports the role of episodic retrieval in future episodic
simulation in a psychiatric population. Future work could expand the
investigation of episodic retrieval in episodic simulation to other psy-
chiatric populations.

Overall, the evidence indicates that episodic retrieval is a likely
mechanism of future simulation impairment in psychiatric populations.
Thus, individuals with psychiatric conditions may have difficulty
imagine the future as a consequence of difficulty retrieving and
recombining episodic details. This conclusion is supported by research
that found overlap between episodic memory and simulation in various
psychiatric populations, and improved future simulation performance in
patients with depression after the experimental manipulation of episodic
retrieval. The relevant research has focused on objective measures of
future simulation. As a result, it is unclear how episodic retrieval may
impact subjective experience during future simulation in patients with
psychiatric conditions.

3.2. Scene construction

Scene construction was defined by Hassabis and Maguire (2007, p.
299) as “the process of mentally generating and maintaining a complex
and coherent scene or event.” Researchers have proposed that scene
construction is a cognitive mechanism that supports both memory and
imagination (Hassabis & Maguire, 2007, 2009; Mullanly & Maguire,
2014). Theoretically, patients with psychiatric conditions may not be
effective to effectively simulate the future if they cannot construct a spatially
coherent scene. However, scene construction has been minimally
investigated in psychiatric populations. Raffard et al. (2010) asked
participants with schizophrenia and controls to simulate atemporal
and future scenarios using the scene construction task (Hassabis et al.,
2007), which includes both subjective and objective ratings to assess the rich-
ness of descriptions. Raffard et al. (2010) found that individuals with
schizophrenia were impaired on atemporal scenarios (i.e., scene con-
struction) and future simulation using the scene construction task
(Hassabis et al., 2007). Specifically, patients with schizophrenia pro-
vided simulations characterized by poorer quality and fewer sensory and
spatial details when compared to controls. Additionally, patients with
schizophrenia rated their perceived sense of presence, salience, and
spatial coherence lower when compared to controls. Some researchers
have proposed that impairment across both simulation of atemporal
scenes and future simulation suggests that impairment in episodic
simulation tasks may be due to deficits in scene construction (Hassabis &
Maguire, 2007, 2009; Palombo, Hayes, Peterson, Keane, & Verfaellie,
2016). However, impaired performance across scene construction and
episodic simulation tasks could be due to a common cognitive mecha-
nism, such as impaired episodic retrieval (Schacter & Madore, 2016), or
perhaps a component of episodic retrieval referred to as event con-
struction (see Romero & Moscovitch, 2012). Event construction is similar
to scene construction in that it refers to the mental assembly of people,
places, objects, and actions that constitute an event, except that event
construction, unlike scene construction, does not place special emphasis
on the spatial coherence of a constructed event. Thus, this may explain
why patients with schizophrenia in Raffard et al. (2010) were impaired
on both scene construction and future simulation tasks, because both
cognitive tasks rely on event construction processes that are compo-
mised in schizophrenia.

Minimal research has investigated scene construction as a mecha-
nism of episodic simulation impairment in psychiatric conditions and is
thus far inconclusive. Limited findings tentatively support that the idea
that patients with schizophrenia have difficulty producing detailed and
salient future simulations as a result of poor mental construction of a
spatially coherent scene. However, impairment across both scene con-
struction and episodic simulation tasks may be attributable to a common
cognitive mechanism, such as the event construction component of
episodic retrieval.

3.3. Mental imagery

Mental imagery has been defined as the simulation or re-creation of a
perceptual experience (Heyes, & Holmes, 2013; Kosslyn, Ganis, &
Thompson, 2001; Pearson, Deeprose, Wallace-Hadrill, Burnett; Pearson,
Naselaris, Holmes, & Kosslyn, 2015). Holmes and Mathews (2010)
stated that mental imagery involves more than mental images and “can
involve multiple sensory modalities, including bodily sensations and
feelings, and can represent complex actions and events that change over
time.” Mental imagery can be voluntary or involuntary (Holmes &
Mathews, 2010; Pearson, Deeprose, Wallace-Hadrill, Burnett Heyes,
Holmes, & Holmes, 2013) and can be neutral or emotionally-valenced (Holmes &
Mathews, 2010). Mental imagery has been conceptualized and exam-
ined in many ways in psychiatric populations (for an in-depth review,
see Pearson et al., 2013). Here we focus on four basic cognitive aspects
of mental imagery that were proposed by Kosslyn and colleagues, which
include image generation, maintenance, inspection, and trans-
formation/manipulation (Kosslyn, 1981, 1995, pp. 267–296). These
processes provide the cognitive building blocks that enable the ability
to engage in mental imagery. Research has investigated the basic cognitive
aspects of mental imagery in psychiatric populations. Findings from
these studies, as discussed below, may clarify whether these abilities
could contribute to episodic simulation impairment in psychiatric pop-
ulations. However, only one study has examined both the cognitive as-
pects of mental imagery and episodic simulation (Di Simplicio et al.,
2016).

Image generation. Image generation is “the ability to form visual
images” (Dror & Kosslyn, 1994, p. 90). Most studies suggest that patients
with psychiatric conditions have generally intact image generation ac-
curacy (e.g., accurately generating previously learned images in space)
(e.g., Alemán, de Haan, & Kahn, 2005; Di Simplicio et al., 2016; Zar-
rinpar, Deklin, & Kosslyn, 2006), but they have slower response times
when generating an image (e.g., Amir, Najmi, & Morrison, 2012;
Cocude, Charlot, & Denis, 1997; Morrison, Amir, & Taylor, 2011; Zar-
rinpar et al., 2006). It is possible that patients with psychiatric condi-
tions exhibit impaired episodic simulation because they are slower at
generating images. Alternatively, the ability to accurately generate an
image may depend on the familiarity of stimuli and working memory
(Matthews, Collins, Thakkar, & Park, 2014), which may be relevant to
simulation of novel future scenarios. However, further support for these
hypotheses are needed.

**Image maintenance.** Image maintenance is “the ability to retain images over time.” (Dror & Kosslyn, 1994, p. 90). Image maintenance tasks tend to involve showing participants an image and, after a delay, participants are asked to recall details or the location of the image. Overall, patients with schizophrenia showed the most consistent deficits in image maintenance (e.g., Fleming et al., 1997; Lee, Folley, Gore, & Park, 2008; Park & Holzman, 1992; Park, Puschel, Sauter, Rentsch, & Hell, 1999; Piskulic, Oliver, Norman, & Maruff, 2007). Based on these findings, one could hypothesize that patients with schizophrenia are impaired at episodic simulation due to difficulty maintaining mental images.

Patients with anxiety, bipolar disorder, and depression exhibit impairments in visuospatial working memory, which may be relevant to the literature on image maintenance (see reviews that discuss these deficits in anxiety (Moran, 2016), bipolar disorder (Soraggi-Frez, Santos, Albuquerque, & Malloy-Diniz, 2017), and depression (Baune, Puhr, Air, & Hering, 2014; Rock, Roiser, Riedel, & Blackwell, 2014; Snyder, 2013)). Research has been variable in patients with bipolar disorder (e.g., Di Simplicio et al., 2016; Pan, Hsieh, & Liu, 2011; Park & Holzman, 1992), so it is unclear if difficulty maintaining a mental image contributes to episodic simulation impairment in this population. Cocude et al. (1997) suggested that patients with depression can maintain images a similar length of time as controls. Future research could examine which aspects of image maintenance are impaired in depression, which could determine its relevance for their ability to simulate the future.

**Image inspection.** Image inspection involves interpreting a characteristic of a generated mental image (Dror & Kosslyn, 1994; Pearson et al., 2013). Image inspection findings are variable in patients with schizophrenia (e.g., Aleman, Bocker, Hijman, de Haan, & Kahn, 2003; Aleman et al., 2005; David & Cutting, 1993), and minimal research has been conducted in other populations such as social phobia (e.g., Amir et al., 2012) and bipolar disorder (e.g., Di Simplicio et al., 2016). Thus, it is unclear whether difficulty inspecting aspects of mental images contributes to episodic simulation impairment in psychiatric populations.

**Image transformation and manipulation.** Image transformation and manipulation refers to the ability to rotate or otherwise alter an imagined image (Dror & Kosslyn, 1994, p. 90). An example task includes presenting hands at different orientations and participants are asked to judge whether the hand is the right or left hand (Chen et al., 2013; de Vignemont et al., 2006; Mazhari, Tabrizi, & Nejad, 2015; Parsons, 1987). Another task involves presenting letters or numbers at different orientations and participants are asked to decide if the letter or number is in the correct orientation or a mirror image (Chen et al., 2013, 2014; de Vignemont et al., 2006; Rogers et al., 2002).

Slower speed during image transformation was found across multiple studies in patients with schizophrenia (e.g., de Vignemont et al., 2006; Jiménez, Mancini-Marie, Lakis, Rinaldi, & Mendrec, 2010; Knight, Manoach, Elliott, & Hershenson, 2000; Mazhari et al., 2015), as well as patients with depression (e.g., Chen et al., 2013; Chen et al., 2014; Rogers et al., 2002; Zarrinpar et al., 2006) and individuals with higher trait anxiety (Kaliner & Jansen, 2014). Speed of image transformation and manipulation was found to be intact in patients with bipolar disorder (Di Simplicio et al., 2016). One hypothesis is that certain psychiatric populations have impaired episodic simulation because they are slower at transforming and manipulating images.

**Mental imagery and episodic simulation.** One study has investigated both of the basic cognitive processes of mental imagery (i.e., image generation, maintenance, inspection, and transformation/manipulation) and episodic simulation of future events using the PIT in patients with bipolar disorder (Di Simplicio et al., 2016). Di Simplicio and colleagues found that patients with bipolar disorder largely did not exhibit impairments in cognitive aspects of mental imagery when compared to controls. However, patients with bipolar disorder reported altered subjective experience during future simulation, as they rated negative future events as more vivid than controls. Notably, these authors did not examine the relationship between the basic generative aspects of mental imagery and episodic simulation.

The finding that basic mental imagery was intact suggests that basic mental imagery impairment (i.e., difficulty generating, maintaining, inspecting, or transforming/manipulating a mental image) probably does not explain their altered subjective future thinking. This finding may not be surprising, given previous work did not find consistent deficits in basic mental imagery processes in patients with bipolar disorder. Additionally, there is currently not a theoretical basis for understanding how basic mental imagery abilities could contribute to altered subjective experience during future simulation, such as enhanced vividness for future negative events and/or diminished vividness for positive events. Impaired basic mental imagery processes may lead to difficulty retrieving episodic details when simulating the future (i.e., performance on objectively measured future simulation tasks), but this possibility has not been examined.

Further research on mental imagery and future simulation is needed. Mental imagery may contribute to future simulation in other populations, such as patients with schizophrenia, and could be examined in future research. As noted by Pearson et al. (2013) in their comprehensive review of mental imagery in psychiatric populations, future research should take generalized cognitive deficits into account, such as slowed processing speed and executive dysfunction.

### 3.4. CaRFAX: Rumination, functional avoidance, and executive dysfunction

The CaRFAX model (Williams, 2006; Williams et al., 2007) enumerates cognitive mechanisms of overgeneral (i.e., less specific) memory in psychiatric populations, including rumination, functional avoidance, and executive dysfunction. Some researchers have examined whether these same cognitive mechanisms may explain impairment in future episodic simulation in psychiatric populations. Components of the CaRFAX model have been examined mainly in studies using objective measures of episodic simulation.

**Rumination.** Rumination is defined as repetitive and passive thinking about one’s negative mood states and the possible causes and consequences of one’s negative mood (Nolen-Hoeksema, 1991). According to the CaRFAX model, rumination results in overgeneral memory because simulating the past triggers the analysis of self-relevant information (Williams, 2006). Theoretically, rumination may also interfere with simulating detailed future events because one’s thoughts are focused on their negative mood.

Rumination has been investigated in a few studies examining future simulation in psychiatric populations. Addis et al. (2016) examined the simulation of specific and plausible future events using the modified AMT and self-reported rumination using the Rumination Subscale of the Rumination Reflection Scale (RRS) (Trapnell & Campbell, 1999). The Rumination Subscale of the RRS assesses the brooding style of rumination by asking participants to rate the level of agreement with items on a 5-point scale (1 = strongly disagree to 5 = strongly agree). An example item is “I always seem to be ‘re-hashing’ in my mind recent things I’ve said or done.” Addis et al. (2016) did not find a significant relationship between rumination and the proportion of specific future events in patients with depression. Using the same rumination and episodic simulation measures, Hach et al. (2014) found elevated rumination and a lower proportion of specific events during episodic simulation in depressed individuals, though they did not examine the relationship between the two variables. Gehrt et al. (2019) asked clinical participants (OCD and health related anxiety) and controls to imagine every day and anxiety related future events. When compared to controls, clinical participants rated their experience higher on various qualities including rumination (“When the event comes to mind I usually keep thinking about it”), vividness, mental time travel, and emotional intensity. Because Gehrt et al. (2019) did not examine the relationship between rumination and vividness ratings, it is unclear if they were
associated. Thus, findings in clinical populations currently do not provide adequate evidence for the role of rumination in the alteration of future simulations.

Studies completed in non-clinical populations produced variable results. Sansom-Daly, Bryant, Cohn, and Wakefield (2014) experimentally manipulated rumination by randomly assigning non-clinical participants to a rumination condition or a control condition. They found that the rumination condition resulted in generation of less specific future events when the events were related to illness concerns. One study found that more frequently engaging in ruminative thought patterns when sad or down was related to a lower number of specific future events in response neutral words (Marsh et al., 2018). Alternatively, Belcher and Kangas (2015) did not find a relationship between rumination (i.e., reflection, brooding, and depression related) and the proportion of specific future events using the modified AMT. Hallford et al. (2019) instructed a non-clinical population to rate their rumination on a visual analogue scale (“Indicate how much you are mulling things over in your head right now that have happened to you in the past”). Hallford et al. (2019) found that rumination was not significantly associated with future specificity, as assessed by the AMT. Similarly, Robinaugh, Lubin, Babic, and McNally (2013) did not find a significant relationship between the tendency to engage in perseverative and repetitive negative thought and the specificity of future simulations using the SCEPT. Given variable findings, it is unclear whether rumination interferes with the ability to simulate detailed future events in psychiatric and non-clinical populations. It is also unclear how and if rumination contributes to altered subjective experience during future simulation. There is currently insufficient evidence to suggest that rumination is a mechanism of episodic simulation, though few studies have investigated this relationship.

Future work could examine the role of attention, working memory, and inhibition in the relationship between rumination and future simulation. Some research suggests that rumination results from difficulty inhibiting negative information held in working memory (Joor- man, 2010), impaired attentional disengagement from persistent negative self-referent information (Koster, De Lijsnyder, Derakshan, & De Raedt, 2011), and a narrow attentional scope (Whitmer & Gottlib, 2013). It is possible that individuals with psychiatric conditions may also have difficulty retrieving detailed future simulations because they cannot inhibit or disengage from negative self-information, or they cannot broaden their attentional scope to relevant details. This idea may also explain why some psychiatric populations have difficulty experiencing future positive events in a vivid manner.

**Functional avoidance.** According to the CaRFAX model, functional avoidance occurs when individuals engage in the retrieval of overgeneral memories to regulate emotion, given that retrieving specific memories results in greater affective disturbance (Williams, 2006). Individuals may also retrieve overgeneral future simulations to regulate their emotion, especially in psychiatric populations. However, there is currently little evidence to suggest that avoidance contributes to future simulation deficits in psychiatric populations. In patients with depression, Addis et al. (2016) did not find a significant relationship between avoidance (using the Cognitive and Behavioral Avoidance Scale (CBAS); Ottenbreit & Dobson, 2004) and the specificity of future simulation (using the modified AMT). Belcher and Kangas (2014) reported similar results: they found no relationship between the specificity of future episodic simulations using the modified AMT and the severity of avoidant maladaptive style. Hach et al. (2018) examined higher avoidance and impaired specificity of future events using the modified AMT in individuals with depression when compared to control subjects, but the relationship between the two variables was not examined. Gehrt et al. (2019) asked clinical participants (OCD and severe health-related anxiety) and controls to imagine every day and anxiety related future events. The clinical participants rated their experience higher on various qualities, including avoidance (“When the event comes to mind I usually try and push it away from my mind”), vividness, mental time travel, and emotional intensity. However, they did not examine the relationship between vividness and avoidance ratings. Overall, most evidence suggests that avoidance is not a mechanism that contributes to episodic simulation impairment in psychiatric populations. Specifically, avoidance of affective disturbance may not be the reason that patients with psychiatric conditions report future simulations with less episodic detail. Future work could examine whether avoidance has a role in altered subjective experience during future simulation.

**Executive functioning.** The CaRFAX model suggests that deficits in executive control or capacity can interfere with the ability to engage in retrieval of a specific past event (Williams, 2006). Executive dysfunction may also interfere with the ability to retrieve specific future events. The relationship between executive functioning and future simulation in psychiatric populations depends on how executive functioning is measured. Speeded word generation from a particular class (i.e., phonemic fluency) was not significantly related to future simulation in patients with depression (Addis et al., 2016; Parlar et al., 2016), PTSD (Brown et al., 2014), schizophrenia (D’Argembeau et al., 2008; Raffard et al., 2016), and bipolar disorder (Boulanger et al., 2013). Boulanger et al. (2013) did not find a relationship between inhibition using the Stroop task and the generation of specific future events using the modified AMT in patients with bipolar disorder. Other studies failed to find a significant relationship between future simulation and task switching (Addis et al., 2016; Parlar et al., 2016) or planning (Addis et al., 2016) in patients with depression. Working memory was not significantly related to future simulation in patients with depression (Addis et al., 2016), and bipolar disorder (Boulanger et al., 2013), though there were variable findings in schizophrenia (Yang et al., 2018, 2019). By contrast, other measures of executive functioning have been significantly associated with future simulation. Addis et al. (2016) found a relationship between strategic retrieval (i.e., CVLT-II semantic clustering) and the specificity of future simulation using the AMT in depression. Parlar et al. (2016) found a relationship between executive functioning (cognitive flexibility as measured by the Wisconsin Card Sorting Task and sustained attention using the Continuous Performance Test) and future simulation (i.e., internal details using the adapted AI task) in patients with depression and history of trauma.

Overall, the evidence thus suggests that certain aspects of executive functioning may be related to episodic simulation in psychiatric conditions. Specifically, deficits in strategic retrieval, cognitive flexibility, and sustained attention may contribute to difficulty simulating detailed future events. Future work is needed to examine if these factors also contribute to altered subjective experience in psychiatric populations.

**Summary.** Overall, there is inconsistent support for components of the CaRFAX model as candidate cognitive processes that influence episodic simulation in psychiatric populations. Variable results were found for rumination and there was a lack of significant results for avoidance. One possible reason for the lack of significant findings for rumination and avoidance is that these effects may depend on the emotional valence of cues, and most of the studies either did not include emotionally valenced cues (Hach et al., 2014; Marsh et al., 2018; Robinaugh et al., 2013) or examined the relationship between episodic simulation and the CaRFAX factors (rumination and avoidance) across all cues regardless of valence (Addis et al., 2016; Belcher & Kangas, 2014, 2015; Hallford et al., 2019). The findings for rumination may be attributable to the severity of clinical symptoms, as multiple studies were conducted in non-clinical populations (Belcher & Kangas, 2015; Hallford et al., 2019; Marsh et al., 2018; Robinaugh et al., 2013; Sansom-Daly et al., 2014). However, Sansom-Daly et al. (2014) and Marsh et al. (2018) reported significant findings for rumination in a non-clinical samples, and Marsh et al. (2018) used neutral cues. Specific aspects of executive functioning may impact episodic simulation in psychiatric populations, such as strategic retrieval, cognitive flexibility, and sustained attention, though evidence is limited.
3.5. Narrative style

Narrative style refers to the manner in which people talk about their experiences and the communicative goals that they seek to achieve (e.g., Labouvie-Vief & Blanchard-Fields, 1982). Thus, any general change in how one communicates about their experience may impact future simulation. Narrative style has been investigated in older adults as a potential cognitive mechanism contributing age-related changes in episodic simulation (Gaesser, Sacchetti, Addis, & Schacter, 2011; Madore et al., 2014; reviewed by: Schacter, Devitt, & Addis, 2018; Schacter, Gaesser, & Addis, 2013). Gaesser et al. (2011) investigated performance across memory, future episodic simulation, and picture description tasks in older adults. They found that older adults showed reduced internal details and increased external details across memory, episodic simulation, and picture description tasks when compared to young adults (on picture description tasks, internal details were defined as details that were physically present in the picture, e.g., details concerning physically present objects, people, actions, places). Gaesser et al. (2011) argued that picture description does not rely on episodic retrieval, therefore concluding that non-episodic factors contributed to the older adults’ impaired performance across all three tasks, such as age-related changes in narrative style. For example, older adults experience increased off-topic speech, disinhibition, and different communication goals when compared to younger adults (Arbuckle & Gold, 1993; Labouvie-Vief & Blanchard-Fields, 1982; Trunk & Abrams, 2009).

Such factors can influence performance on the modified AI task used to assess remembered past and imagined future experiences, thus must be considered when impairments in older adults or patient populations are observed on these and related tasks. However, subsequent research using the ESI showed that episodic retrieval in young and old adults can be distinguished from the influence of narrative style (Madore et al., 2014).

Narrative style may be a factor that impacts episodic simulation performance in psychiatric conditions. Narrative style seems especially relevant for patients with depression, bipolar disorder, and schizophrenia. Psychomotor retardation is a symptom that is characteristic of depression, and has been found to result in slowed speech (Scrijvers, Hulstijn, & Sabbe, 2008; Sobin & Sackheim, 1997). During periods of mania or hypomania, patients with bipolar disorder present with a “flight of ideas” and pressured speech (Anderson, Haddad, & Scott, 2012; Cassidy, Murry, Forest, & Carroll, 1998). Patients with schizophrenia present with disorganized speech, which presents as speech being tangential or having loose associations (Covington et al., 2005; Roche, Creed, MacMahon, Brennan, & Clarke, 2014; Schultz & Andreasen, 1999). Patients with schizophrenia also present with poverty of speech (Foussias & Remington, 2008; Schultz & Andreasen, 1999).

Theoretically, if patients’ thought content is slowed, pressured, or disorganized, it may interfere with retrieving future episodic details. As a result, patients may report more off-topic and non-specific details when simulating the future rather than rich episodic details, or they may experience future simulations with less vividness. Based on the findings from Gaesser et al. (2011), narrative style may not only impact future simulation in patients with psychiatric conditions, but also their descriptions of their current and past experiences.

However, narrative style has been studied infrequently in psychiatric conditions. A few studies have found impaired “coherence” when communicating future descriptions in schizophrenia, which possibly could reflect the impact of disorganized speech on episodic simulation performance. Huddy et al. (2016) found that patients with schizophrenia and schizoaffective disorder communicate with less coherence, as objectively rated by examiners, when simulating hypothetical scenarios when compared to controls. Painter and Kring (2016) asked participants to generate specific future events, and experimenters rated the clarity of episodic simulation in patients with schizophrenia and schizoaffective disorder. A narrative was rated “clear” if it was organized and easy to understand, “moderately clear” if the narrative was relatively understandable, but at times the content was difficult to understand or follow, and “unclear” if the narrative was difficult to follow or disorganized. Painter and Kring (2016) found that individuals with schizophrenia and schizoaffective disorder had episodic simulations that were rated as having lower clarity than controls when responding to negative cues. Anderson and Evans (2015) found individuals with dysphoria rated their experience while simulating the future as having lower coherence when compared to controls (i.e., order of events is less clear and tells less of a coherent story).

Overall, studies have found compromised clarity or coherence of future simulations in psychiatric populations. These findings provide preliminary evidence that narrative style may contribute to poor simulation in psychiatric populations. However, no studies have directly examined the relationship between these two constructs in psychiatric populations, so the impact of narrative style on future simulation is still an open question. Future work could directly examine the relationship between disorganized speech and episodic simulation in schizophrenic patients, and could also examine additional factors that may influence narrative style in psychiatric patients, including psychomotor retardation, pressured speech, or paucity of speech. This research could help determine if narrative style accounts for altered episodic simulation performance in psychiatric conditions, or if their performance is better accounted for by other cognitive mechanisms.

4. Summary and conclusion

This paper reviewed studies that investigated episodic simulation performance in psychiatric populations and the cognitive processes that may contribute to their ability to engage in episodic simulation. Studies using objective measures of episodic simulation have found that patients with psychiatric conditions provide future simulations with fewer specific details and fewer details tied to a specific time and place. Some evidence also suggests that patients with psychiatric conditions have altered subjective experiences during future simulation, reporting their subjective experiences as diminished or enhanced compared to controls.

Various cognitive processes have been proposed as potential mechanisms of episodic simulation impairment in psychiatric conditions, including episodic retrieval, scene construction, mental imagery, elements of the CARFAX model (avoidance, rumination, and executive functioning), and narrative style. Based on the current literature, evidence suggests that episodic retrieval is a likely mechanism of episodic simulation impairment in certain psychiatric populations. There is less evidence available concerning the closely related construct of scene construction, which emphasizes spatial aspects of imagined events. Future research should more closely examine whether patients with psychiatric conditions exhibit impairments in episodic simulation because of difficulty generating spatial relations when constructing imagined scenes, or because of problems recombining and integrating both spatial and non-spatial aspects of event representations. There is as yet limited evidence that deficits in mental imagery (i.e., image generation, image maintenance, image inspection, and image transformation/mannipulation) contribute to episodic simulation deficits in psychiatric populations. However, both mental imagery and episodic simulation have been investigated together only in patients with bipolar disorder. Thus, further research is needed to determine whether mental imagery contributes to episodic simulation in other psychiatric populations. For example, patients with schizophrenia present with impairments in image maintenance, which may be relevant for future simulation.

Certain aspects of the CARFAX model, namely avoidance and rumination, have so far received limited support as mechanisms of episodic simulation impairment in psychiatric disease. However, problems with aspects of executive functioning may contribute to episodic simulation performance in psychiatric populations, such as strategic retrieval, cognitive flexibility, and sustained attention. Lastly, narrative style may impact the ability to clearly and coherently communicate future simulations in patients with psychiatric conditions, but much more research
on this topic is needed. Taken together, research to-date provides initial insights into the cognitive factors that may underlie episodic simulation impairment in psychiatric populations, but it seems likely that multiple cognitive processes impact patients’ ability to simulate the future.

4.1. Assessment of the strength of the evidence

The strength of the evidence differs by candidate mechanism. Episodic retrieval has substantive correlational evidence that suggests episodic retrieval is associated with future simulation in psychiatric populations. Episodic retrieval is also the only mechanism that has causal evidence supporting its involvement in individuals with depression. Regarding executive control, correlational studies have found a significant association between certain aspects of executive control and future simulation in psychiatric populations. For the remaining mechanisms, there is insufficient evidence to determine whether they contribute to compromised future simulation in psychiatric populations. Specifically, correlational findings between rumination and future simulation are variable, and the few correlational studies for avoidance suggest there is not a significant relationship with future simulation. For scene construction, mental imagery, and narrative style, findings are speculative, since correlational or experimental studies have not directly examined the relationships between future simulation and these potential mechanisms. Based on the current literature, episodic retrieval/simulation seems to be a transdiagnostic mechanism given at least correlational evidence in multiple psychiatric populations. The remaining candidate mechanisms were examined in one or two psychiatric populations, so it is currently unclear if these mechanisms are transdiagnostic.

The focus of the current paper is to review mechanisms of future simulation in psychiatric populations. However, the proposed mechanisms are likely relevant for future simulation in other populations, such as healthy individuals or patients with neurological conditions. For example, there is correlational evidence for episodic retrieval as a mechanism in neurological (Addis, Sacchetti, Ally, Budson, & Schacter, 2009; El Haj, Antoine, & Kapogiannis, 2015; Gamboz et al., 2010) and non-clinical older adult populations (Addis et al., 2008; Addis, Muscari, Pan, & Schacter, 2010). Episodic retrieval has also been found to have a causal relationship with future simulation in non-clinical young and old individuals (Madore et al., 2014). Additionally, executive functioning has been associated with future simulation in healthy individuals (D’Argembeau, Ortolova, Jumentier, & Van der Linden, 2010). Future work will be needed to assess whether the remaining mechanisms are relevant across non-clinical, neurological, and psychiatric populations.

While progress has been made in identifying cognitive processes that impact episodic simulation performance in psychiatric populations, there are gaps in the literature. The cognitive mechanisms discussed above have only been explored in certain populations. It is possible that specific cognitive processes may contribute to episodic simulation impairment in one psychiatric population, but not another. For example, patients with anxiety do not tend to present with deficits in their narrative style. However, alterations in narrative style are characteristic of other conditions, such as disorganized speech in schizophrenia, which may impact their performance on an episodic simulation task. An important task for future research is to identify the cognitive processes that contribute to episodic simulation performance in each psychiatric population. A promising area for additional research would be to examine the potential bidirectional relationship between the candidate mechanisms and future simulation. For example, rumination may interfere with retrieval of detailed future simulations, and engaging in future simulation may activate thoughts about the self, resulting in repetitive and passive thinking about one’s mood states. However, this work has not been reported.

A limitation of the current literature is that some cognitive processes have been examined only in relation to either objective or subjective measures of episodic simulation. This is an important area of future research, as cognitive processes discussed above may not contribute similarly to performance on objective measures of episodic simulation (such as the specificity of future descriptions) and the patient’s subjective experience. Patients with psychiatric conditions do not perform consistently across objective and subjective measures of episodic simulation, which suggests that underlying cognitive processes are likely not impacting their performance similarly across both measures. For example, Addis et al. (2016) found that patients with depression produced episodic simulations with reduced specificity when compared to controls (as objectively rated by researchers), even though their subjective ratings of detail and emotional intensity did not differ significantly from controls. Future work could attempt to determine whether different cognitive mechanisms impact subjective experience during episodic simulation and objective performance.

The current review focused on episodic simulation. As discussed previously, there are other types of prospect, such as prediction, intention and planning (Szpunar et al., 2014). Research has found impairments across different types of prospect in patients with psychiatric conditions (for an in-depth review, see MacLeod, 2017). Future work will be needed to examine whether the same mechanisms explain impairment in other types of prospect in psychiatric conditions.

4.2. Clinical implications

The cognitive processes that influence episodic simulation performance in psychiatric populations could inform interventions. Interventions have been developed to improve specificity and reduce overgeneralization during autobiographical memory and future thinking. Substantial research has been conducted examining interventions targeting autobiographical memory specificity in psychiatric populations (Barry, Sze, & Raes, 2019; Erten & Brown, 2018; Hitchcock, Werner-Seidler, Blackwell, & Dalgleish, 2017). Outcomes of these interventions include improved performance on autobiographical memory tasks (i.e., increased specificity of memories) and improvements in psychological well-being across various psychiatric populations (Barry et al., 2019; Erten & Brown, 2018; Hitchcock et al., 2017). The impact of episodic specificity induction on future episodic simulation has been examined in non-clinical populations, which found improved psychological well-being (Jing et al., 2016) and reappraisal of negative future events (Jing, Madore, & Schacter, 2017). It is unknown, however, whether these effects impact everyday function, and because these studies were completed in healthy individuals, the findings need to be replicated in patients with psychiatric conditions. McFarland et al. (2017) found improved problem-solving in patients with depression after a specificity induction. Interventions to improve specificity when simulating positive future events have also been beneficial, as these interventions have led to improvements in positive affect (Schubert, Eloo, Scharfen, & Morina, 2020) and promoted engagement in behavioral activation (Renner, Ji, Pictet, Holmes, & Blackwell, 2017). Specifi city interventions for episodic simulation may be useful for targeting psychological well-being in psychiatric populations. In clinical practice, therapists may be able to also integrate specificity training into empirically-based interventions, such as confirming their patients are simulating future events in a specific manner when planning behavioral activation activities or when completing exposure therapy about feared future experiences.

Cognitive factors that potentially contribute to episodic simulation impairment in psychiatric populations, such as episodic memory retrieval, scene construction, mental imagery, components of the CaPAX model (capture and rumination, functional avoidance, and executive control dysfunction), and narrative style, may also help to explain patients’ improvements from specificity interventions. A meta-analysis by Barry et al. (2019) examined potential contributors underlying improved mood and memory specificity following memory specificity training, including executive functioning and rumination. Barry et al. (2019) found that the specificity intervention resulted in improved
executive functioning (i.e., verbal fluency). However, variable findings were present for rumination. Barry et al. (2019) noted that few studies explored these factors, so further research is needed. Targeting the relevant cognitive mechanisms underlying compromised episodic simulation in each psychiatric population could result in tailored and hopefully more effective treatment approaches.

Future work could enhance our understanding of the clinical implications of future simulation. There is ample evidence that future simulation is compromised in psychiatric populations. However, the current studies in psychiatric populations are cross-sectional and do not yet address whether future simulation is a cause or consequence of the disorder. Researchers have hypothesized that compromised future thinking may lead to the maintenance of psychiatric disease (Miloyin, Pachana, & Suddendorf, 2014; Roepke & Seligman, 2016), though this is also an open question. Increased knowledge regarding the clinical implications of future simulation should help to inform whether future simulation interventions are warranted in psychiatric populations.

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**CRediT authorship contribution statement**

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None.

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