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SHORT REPORT

A matter of precision? Scene imagery in individuals with high-functioning autism spectrum disorder

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Abstract

The ability to create mental representations of scenes is essential for remembering, predicting, and imagining. In individuals with autism spectrum disorders (ASD) this ability may be impaired. Considering that autistic characteristics such as weak central coherence or reduced communication abilities may disadvantage autistic participants in traditional imagery tasks, this study attempted to use a novel task design to measure the ability of scene imagery. Thirty high-functioning adults with ASD and 27 non-autistic matched control adults were asked to describe imagined fictitious scenes using two types of scene imagery tasks. In a free imagery task, participants were asked to imagine a scene based on a given keyword. In a guided imagery task, participants had to imagine a scene based on a detailed description of the scene. Additionally, narrative abilities were assessed using the Narrative Scoring Scheme. Statistical analyses revealed no group effects in the free and guided imagery of fictional scenes. Participants with ASD performed worse than control participants in the narrative task. Narrative abilities correlated positively with performance in both imagery tasks in the ASD group only. Hence, individuals with ASD seem to show as good imagery abilities as non-autistic individuals. The results are discussed in the light of the differences between imagery and imagination and possible gender differences.

Lay Summary

The ability to imagine is an essential basis for a wide range of cognitive functions such as thinking about the future, remembering past information, or fantasizing about (im)possible events. Previous studies suggest impairments in imagery abilities in individuals with autism spectrum disorders. However, we hypothesize that the traditional task designs used in past studies may have disadvantaged individuals with autism spectrum disorder (ASD) given the tasks' high demands on fantasy, verbal ability, and central coherence which are often compromised in ASD. Using a novel approach—taking the characteristic neural processing style in ASD into account—, we aim to re-examine imagery in this population.

KEYWORDS

autism spectrum disorders, imagery, narrative abilities, scene construction

INTRODUCTION

Autism spectrum disorders (ASD) are characterized by impairments in social interaction, cognitive flexibility, and a restricted range of activities and interests. Severity of symptoms differs in each individual and can change across the lifespan (American Psychiatric Association, 2013). Studies have shown a male predominance; with ASD affecting two or three times more males than females (e.g., Kim et al., 2011). However, this diagnostic distribution toward males might result from under-recognition of females with ASD (Baron-Cohen et al., 2011).

Recent studies suggest a 3:1 male-to-female ratio (Loomes et al., 2017; Wilson et al., 2016).

Difficulties in three cognitive domains have been mainly considered to be characteristic of ASD: Deficits in theory of mind (ToM, i.e., the ability to attribute mental states like beliefs, desires, or intentions to others to explain and predict their behavior; e.g., Baron-Cohen et al., 1985), reduced central coherence (WCC, i.e., the tendency to process information locally; see Happé et al., 2001, Happe & Frith, 2006) and executive dysfunction (see Hill, 2004). In recent years, the alternative perceptual processing style in individuals with ASD has gained the interest of research. The enhanced perceptual functioning model (EPF, Mottron et al., 2006; Mottron & Burack, 2001) states that processing mechanisms underlying the detection, discrimination, and categorization of perceptual stimuli are enhanced in individuals with ASD, leading to a stronger emphasis of perceptual information compared to higher-order cognitive operations in stimulus processing. This might contribute to the enhanced perceptual abilities observed in some individuals with ASD as well as potential difficulties with integrating contextual information or forming coherent higher-level interpretations. A similar account has also been suggested by the predictive coding theory (e.g., Lawson et al., 2014; Pellicano & Burr, 2012; Van des Cruys et al., 2014), with the distinction that here the authors suggest that individuals with ASD only aim to reduce that part of the perceptual input that they cannot predict. The framework suggests that the brain is constantly generating predictions about sensory input and comparing these predictions to actual sensory information. When there is a mismatch between predictions and sensory input, the internal models of the brain are updated to better match the incoming data.

All mentioned perceptual theories suggest that individuals with ASD might rely less on context or prior knowledge and more on the details of the sensory input. This atypical weighting of sensory information could contribute to autistic characteristics such as hypersensitivity (Baum et al., 2015) or low tolerance for uncertainty (Sapey-Triomphe et al., 2021), but also to strengths such as more rational and bias-free decision-making (Rozenkrantz et al., 2021).

A universal executive function (EF) profile for individuals with ASD has not been determined yet (Panerai et al., 2014), however, EF deficits in ASD seem to be present across a range of executive subfunctions. For example, difficulties in planning, organizing, time management, flexibly switching between tasks, emotional or behavioral regulation seem to be common in ASD (see Demetriou et al., 2018). In daily life, EF impairments may evidence in problems with organizing a calendar or the inability to begin or complete a task.

Episodic future thinking (EFT) refers to the ability to imagine events that might occur in one's personal future (Atance & O'Neill, 2001), for example, envisioning taking part in an important exam next week. Several studies found that children (Hanson & Atance, 2014; Lind, Bowler, & Raber, 2014a; Marini et al., 2018; Terrett et al., 2013) and adults with ASD (Lind & Bowler, 2010; Lind, Williams, et al., 2014b) have difficulties to mentally project themselves into a future situation (but see Crane et al., 2013 for spared performance).

Relying mainly on episodic memory and executive control processes, executive dysfunctioning may also limit the ability to imagine one's personal future in ASD (D'Argembeau et al., 2010). Vice versa, a reduced ability to mentally pre-experience future events, hence, to engage in EFT, might result in difficulties to plan upcoming events which is essential to effectively adapt to a dynamic environment and to achieve personal goals (Schacter & Addis, 2007).

Marini et al. (2018) demonstrated that EFT may only be impaired in those autistic children who also have narrative difficulties and thus EFT may not universally be reduced in ASD. In general, research on high-functioning individuals with ASD suggests spared narrative abilities (Colle et al., 2008; Diehl et al., 2006; Losh & Capps, 2003; McCabe et al., 2013; Norbury & Bishop, 2003; Young et al., 2005; but see Capps et al., 2000; Rollins, 2014; Siller et al., 2014 for contrasting evidence). However, individuals with ASD seem to have difficulties with creating cohesion in stories (Colle et al., 2008; Diehl et al., 2006) and expressing their mental and affective states (Capps et al., 2000; Rollins, 2014; Siller et al., 2014).

The ability to create mental representations of scenes is essential for remembering, predicting, and imagining. Cognitive and neuroimaging evidence suggest that these abilities share common mechanisms (Barry et al., 2019). For example, scene construction theory (Hassabis & Maguire, 2007; Maguire & Mullally, 2013) states that retrieval of past (episodic memory; Tulving, 1972) and the prediction of future events (EFT; Atance & O'Neill, 2001; Tulving, 1972), but also the imagination of fictive scenes (scene imagery; Barry et al., 2019) all rely on the process of mentally constructing scenes. Coherent spatial representations are generated by "binding together" elements of a scene in mind, including contextual details such as sounds, smells, feelings, thoughts, people, and objects. Consequently, Hassabis, Kumaran, Vann, and Maguire (2007b) suggested that episodic memory and EFT might share a common neural basis; a network centered on the hippocampus. Indeed, functional magnetic resonance imaging (fMRI) studies in healthy participants provide evidence for an engagement of the hippocampus in autobiographical memory (Cabeza et al., 2004; Moscovitch et al., 2005), spatial navigation (Spiers & Maguire, 2006), imagining fictitious and future scenes (Hassabis, Kumaran, & Maguire, 2007a; Schacter et al., 2007; Szpunar et al., 2007; Zeidman et al., 2015). In addition to the hippocampus, the ventromedial prefrontal cortex (vmPFC), posterior cingulate cortex (PCC) and precuneus (these brain regions are part of the *default* *network*, see Buckner et al., 2008) seem to be recruited during scene construction (Hassabis, Kumaran, Vann, & Maguire, 2007b). Indeed, the process of mentally constructing vivid and spatially coherent scenes seems to be strongly modulated by vmPFC (Barry et al., 2019). Importantly, there is some evidence for hippocampal and vmPFC structural abnormalities in ASD (e.g., Banker et al., 2021; Murphy et al., 2017) which may underlie possible imagery impairments in ASD.

Deficits in EFT in ASD could be caused by a reduced ability to mentally construct scenes as suggested by Lind et al. (2014b). Lind and colleagues asked adults with ASD to describe fictional scenes (assessing scene construction abilities in fictive imagery), events in participants' past as well as possible future events (assessing scene construction abilities in episodic memory and EFT). In addition, their narrative abilities and ToM performance were measured. Participants with ASD performed worse in the imagery (scene construction) and theory of Mind (ToM) tasks, but not in the task measuring narrative abilities. However, performance in the three tasks requiring scene construction (EFT, episodic memory, fictive scenes) was not related to performance in the narrative abilities and theory of mind tasks. Lind and colleagues concluded that the core deficit in ASD lies in scene construction and not self-projection ability, which relies on mentally shifting from one's current perspective to alternative perspectives (see Suddendorf & Corballis, 1997).

Individuals with ASD are not only expected to exhibit impairments in EFT and scene imagery but also in most imagination-related constructs and correlates, such as mentalizing, pretend play, and creativity (see Crespi et al., 2016). However, study results suggesting reduced abilities in imagery in ASD may also seem somewhat counterintuitive, given that individuals with ASD are often perceived as "visual thinkers" with a bias to process information visually rather than verbally (Kunda & Goel, 2011). Indeed, research has shown that they seem to be better at creating and maintaining mental imagery of complex three-dimensional figures (Soulières et al., 2011) and in general, use mental imagery more frequently for language comprehension than non-autistic individuals (Kana et al., 2006). Scott and Baron-Cohen (1996) found difficulties in children with ASD imagining unreal, fictitious objects, but their imagery regarding real objects appeared to be unaffected. Therefore, the question arises as to whether imagery ability in ASD is globally impaired or only becomes evident in specific domains of imagination (cf. more details, Crespi et al., 2016).

Importantly, a major limitation of Lind et al.'s (2014b) study is that scene construction was operationalized by asking participants to provide verbal descriptions of freely generated mental scenes (free imagery) in response to cue words or cue sentences. Instructions were kept short (e.g., "Standing by a small stream, somewhere deep in a forest") and did not go into much detail. This may have disadvantaged participants with ASD. The WCC account suggests that ASD's cognitive style is characterized by "weak" coherence which is reflected in preferentially attending to details at the expense of the meaning or gist of information (Joseph et al., 2009). Furthermore, it has been shown that children with ASD tend to often focus on only one cue at a time while ignoring other cues ("stimulus overselectivity," Lovaas et al., 1971). Therapy approaches like the Mental Imagery Therapy for Autism (MITA; Dunn & Vyshedskiy, 2015) aim to address the challenges of integrating multiple details into a coherent whole in children with ASD. Free imagery tasks—as the one used by Lind et al. (2014b)—may lead to ASD individuals focusing on single details of a scene, rather than imaging or describing it more globally. According to EPF or predictive coding theory, individuals with ASD might rely less on learned knowledge and more on the information provided in the specific situation. However, a reliance on heuristics or scripts could be helpful, if not necessary, when describing a fictional scenario—especially when there is only limited information available. Moreover, individuals with ASD may not spontaneously mention specific details during imagery tasks when they are not explicitly requested to do so (see for similar evidence studies on narrative abilities, e.g., Capps et al., 2000; Ganz & Flores, 2009; Losh & Capps, 2003), even though they may imagine them. Hence, it is possible that rather than autistic individuals' imagery abilities their verbal abilities might be impaired causing them to score lower in free imagery tasks.

The aim of this study was to consider the specific characteristics of individuals with ASD with regards to their verbal abilities and altered processing style when assessing their scene construction ability. Following Lind et al. (2014b), participants were asked to imagine and describe fictitious scenes based on a keyword. In addition to this traditional free imagery task, we conducted a novel guided imagery task. Participants were read scenes with spatial and scenic details, and were asked to imagine them. During the guided scene construction tasks, participants were provided with all elements for "binding a scene in mind" ensuring that there was no uncertainty about specific details of the objects that had to be included in the mental representation and a reduced need to rely on comprehensive metacognitive knowledge about the characteristics of the scenario. Furthermore, we included spatial errors in the descriptions of the to be imagined scenes of the guided imagery task as an additional indicator of scene construction ability. We assumed that participants would notice these errors if they actually imagine the scenes.

To control for narrative ability, we conducted a narrative task, comparable with the one from Lind et al. (2014b). The assessment of scene construction requested participants to give complex verbal descriptions of

TABLE 1 Mean (SD) individual difference variables.

	ASD ($n = 30$)	Controls ($n = 27$)			
	M (SD)	*M* (SD)	$F(1,55)$	p	η^2
Age	34.77 (13.88)	32.00 (11.37)	0.70	0.417	0.012
AQ	24.53 (3.44)	9.48 (3.64)	257.30	0.000	0.824
FEA-ASB	28.30 (11.15)	14.66 (11.05)	21.43	0.000	0.444
WAIS-IV					
Verbal ability	12.4 (3.14)	11.81 (2.25)	0.71	0.402	0.121
Raw score	47.37 (4.88)	46.70 (5.57)	0.077	0.783	0.072
Non-verbal ability[1]	11.66 (3.10)	9.85 (2.31)	6.19	0.016	0.261
Raw score	21.53 (3.89)	19.51 (3.82)	3.87	0.054	0.215

Note: For the WAIS subtests, results are reported in age normed scaled scores ($M = 10$, SD = 3; range 1–19).

Abbreviations: ASD, autism spectrum disorder; AQ, Autism Spectrum Quotient Test; FEA-ASB, Fragebogen zur Erfassung von ADHS im Erwachsenenalter [Questionnaire for the assessment of ADHD in adulthood]; WAIS-IV = Wechsl, Intelligence Scale.

[1]To assess whether the cognitive advantage of the ASD over the control group had an impact on the results of the narrative and imagery tasks, we repeated the analyses with a reduced sample. We excluded four participants of the ASD group with an average age-normed scaled score of higher than 14.5 points and four participants of the control group with an average score of below 9.5 points in the non-verbal and verbal abilities tests. Rerunning analyses with the reduced sample set resulted in no longer significant group differences in the non-verbal, $F(1, 47) = 4.86$, $p = 0.489$ and verbal ability tests, $F(1, 47) = 1.08$, $p = 0.303$. The pattern of significances of the results of the main analyses remained unchanged, with only the NSS scale Character Development no longer showing a significant difference between the groups after the excluding the most able ASD and least able control participants, $F(1, 47) = 2.98$, $p = 0.091$.

imagined events and thus strongly relied on their narrative abilities. A poor performance in scene construction tasks could simply be the result of attenuated narrative ability in ASD.

Using a novel approach, that comprises guided and free imaginations to assess imagery ability, we hoped to gain new insights into the ability of scene construction in ASD. We aimed to investigate whether individuals with ASD are capable of mentally constructing a scene when they are given all relevant details to describe the scene. Following Lind et al.'s (2014b) results, we predicted ASD participants to perform worse than control participants in the free imagery, but we expected spared performance in the guided imagery task.

METHODS

Participants

A total of 57 participants took part in the present study: 30 adults with high-functioning ASD (age $M = 34.77$, range 18–68, $SD = 13.88$; 18 women, 10 men, and 2 diverse individuals) and 27 adults without ASD diagnosis (age $M = 32.0$, range 20–64, $SD = 11.37$; 18 women and 9 men). Groups were parallel for age, highest education degree, and gender. Participants were recruited via mental healthcare facilities (e.g., nationwide autism treatment centers), self-help groups and social media (mainly Facebook). Inclusion criteria were being aged between 18 and 69 years, German mother tongue and for the ASD group a diagnosis of high-functioning autism or Asperger's syndrome. Exclusion criteria were the presence of severe psychiatric or neurological disorders (such as schizophrenia, bipolar disorder or current severe depressive episode or neurological illnesses). Mentioned comorbid disorders were affective disorders such as major depression (50% of participants with ASD) or anxiety disorders (17%), ADHD (10%), and obsessive-compulsive disorder (3%). Comorbid disorders in the control group were major depression (6%) and anxiety disorders (3%).

All participants were asked to indicate the institution and year when they received the ASD diagnosis. All participants completed the German short version of the Autism Spectrum Quotient Test (AQ, Baron-Cohen et al., 2001). Participants with ASD scored between 14 and 30 on the AQ; all except one participant scored above the AQ cut-off of 17 (Sum score = 14). All participants of the control group scored below the cut-off of 17 (range 3–15).

Participant characteristics are presented in Table 1. All participants gave written informed consent prior to taking part in the study. The study was conducted in line with the Helsinki declaration. Ethical approval for the study was obtained from the local university ethics committee. Participants received 10 EUR for taking part in the study.

Online assessment and procedure

First participants were asked to fill in a questionnaire assessing sociodemographic information as well as several psychological self-assessment tests, that should provide insights into the characteristics of the sample. Data were collected via the online platform SoSci Survey (Leiner, 2019).

Individual difference variables
The Autism Spectrum Quotient Test—Short Version, Freitag et al., (2007) is a 33-item screening questionnaire that measures the severity of ASD symptoms if an ASD diagnosis has been already confirmed. Reponses to different statements are given on a 4-point Likert scale. A score of 17 or more indicates clinically significant levels of autistic traits. The FEA-ASB (Döpfner et al., 2006) is a German self-assessment questionnaire measuring symptoms of ADHD in adults. The questionnaire consists of 20 items that measure symptoms of attention deficit, hyperactivity, and impulsivity following ICD-10 and DSM-V criteria on a 4-level Likert-Scale.

After the completion of the questionnaires, an appointment was made with the participants for the assessment of cognitive abilities, scene construction, and narrative ability. The test session took place via a 90-min video conference using the platform BigBlueButton.

To assess participants' verbal and non-verbal abilities, the vocabulary and matrices reasoning subtests of the German version of the Wechsler Intelligence Scale-Fourth Edition (WAIS-IV) were administered (Wechsler, 2008) in the beginning of the video conference. The vocabulary subtest measures word knowledge and the ability to verbally express definitions of words. Matrices reasoning requires individuals to identify patterns in designs. Raw scores were converted to age-scaled scores.

Narrative control task
To assess participants' narrative abilities a 16-paged children's book called "Sailor Bear" (Waddel & Miller, 1992) was used. The story is about the adventures of a little bear who sails on the sea and gets caught in a storm. In the implementation of the task, we were following the procedure of Lind et al. (2014b). The task was rated according to the Narrative Scoring Scheme (NSS; Miller et al., 2003). Further details of the procedure and rating can be found in the Appendix S1.

Free imagery task
Participants were instructed that they would be asked to imagine scenes based on a cue word that would set the scene. Following the procedure of Lind et al. (2014b), the task was rated according to the scoring scheme of (Hassabis, Kumaran, & Maguire, 2007a). The total score ("experiential index score") was calculated by adding up the four subcomponent scores: description content, participants questionnaire ratings, spatial coherence index, and independent quality rating.

A detailed description of the procedure and analysis can be found in the Appendix S1.

Guided imagery task
Participants were instructed that they would be read descriptions of various scenes. They were asked to imagine these scenes and describe their mental representations to the experimenter in as much detail as possible after having listened to the descriptions. Participants were encouraged to continue with their descriptions until they were unable to elaborate further details from memory. Each reading lasted about 1 min. Three of the four scene descriptions contained a spatial incongruity (e.g., sun casts a shadow in the room which is not possible due to the position of the windows), which should be noticeable when the listener really imagined the scene. The fourth scene contained a logical error (e.g., sun sets at the beginning of the reading, later a parasol is set up to protect from the midday sun) to control for possible differences in the recognition of spatial and logical errors. Participants were requested to press a specific button on their keyboard if they felt the description was not coherent or incorrect. After their reproduction of the description, they were asked about their error marks to determine if they had spotted the spatial or logical mistake within the description. The dependent variable was the imagery performance of the participants (self and external ratings), as well as the number of detected logical and spatial mistakes.

To rate the quality of the descriptions of the guided imagery task, per scene description the presence of 10 details in participants' scene description (e.g., color of the carpet in the classroom, position of the swing on the playground) was rated on a scale of 0-8. Details of procedure and scoring can be found in the Appendix S1.

Participants descriptions of the narrative, the free imagery and guided imagery task (nine in total) were audio recorded for later transcription. All transcribed scripts were rated by two independent raters who were blind to the diagnosis of the participant. Interrater reliability for both, the narrative task (NSS total score), Cronbach's $\alpha = 0.98$ and the free imagery task, Cronbach's $\alpha = 0.97$–0.98 were high.

Statistical analysis

The data was analyzed using IBM SPSS Statistics (Version 27). Considering the small sample size, we conducted additional Bayesian statistics to estimate the strength of evidence for the null hypothesis. Bayesian ANOVAs were implemented in JASP (JASP Team 2023, Version 0.17.3). The support for our hypotheses is described by the Bayes factor (BF). The BF_{10} describes the ratio between the evidence for the hypothesis H_1 relative to the null hypothesis H_0 (see van den Bergh et al., 2020).

RESULTS

Narrative control task

A one-way MANOVA showed statistically significant differences between the groups in the subcategories of the

TABLE 2 Mean (SD) narrative task subcategories.

	ASD (n = 30)	Controls (n = 27)				Bayesian ANOVA
	M (SD)	M (SD)	F(1, 56)	p	d	BF_{10}[a]
Introduction	3.93 (0.74)	4.21 (0.77)	3.86	0.054	0.07	1.31
Character development	3.88 (0.75)	4.22 (0.75)	5.27	0.025	0.09	2.31
Mental and emotional states	2.98 (1.46)	4.04 (1.55)	13.95	0.000	0.20	61.1
Referencing/listener awareness	4.12 (0.83)	4.50 (0.86)	5.94	0.018	0.10	2.99
Conflict	3.88 (1.15)	4.30 (1.21)	3.51	0.066	0.06	1.14
Cohesion	3.67 (1.26)	4.00 (1.33)	1.88	0.176	0.03	0.59
Conclusion	3.10 (0.97)	3.02 (1.03)	0.19	0.665	0.03	0.29

Abbreviation: ASD, autism spectrum disorder.
[a]BF_{10} describes the likelihood of the data under H_1 compared to H_0, BF_{10} = 1/3–1/10, moderate evidence for H_0; BF_{10} = 1–1/3, anecdotal evidence for H_0, BF_{10} = 1–3, anecdotal evidence for H_1, BF_{10} = 3–10, moderate evidence for H_1, BF_{10} = 10–30 strong evidence for H_1, BF_{10} = 30–100 very strong evidence for H_1.

TABLE 3 Mean (SD) Experiential Index Score and scores of the subcomponents of the free imagery task.

	ASD (n = 30)	Controls (n = 27)				Bayesian ANOVA
	M (SD)	M (SD)	F(1, 56)	p	d	BF_{10}[a]
Experiential index score (0–60)	36.18 (7.95)	37.90 (5.40)	0.90	0.347	0.25	0.39
Subcomponents						
Content total score	21.35 (3.72)	21.8 (2.75)	0.27	0.609	0.14	0.30
Spatial references (0–7)	4.43 (1.46)	4.26 (0.95)	0.27	0.608	0.14	0.30
Entities present (0–7)	6.38 (0.81)	6.62 (0.55)	1.60	0.211	0.34	0.52
Sensory descriptions (0–7)	4.90 (1.34)	5.11 (1.31)	0.36	0.551	0.16	0.31
Thoughts/emotions/actions (0–7)	5.63 (1.17)	5.81 (1.16)	0.31	0.579	0.15	0.31
Overall rating of description quality (0–18)	6.74 (1.85)	6.83 (1.46)	0.04	0.838	0.05	0.27
Participant ratings						
Sense of presence (0–4)	2.76 (0.79)	2.81 (0.56)	0.07	0.898	0.69	0.27
Perceived salience (0–4)	2.35 (0.82)	2.40 (0.56)	0.07	0.800	0.71	0.27
Spatial coherence index (0–6)	2.92 (2.11)	3.93 (1.70)	3.98	0.051	0.19	1.37

Abbreviation: ASD, autism spectrum disorder.
[a]BF_{10} describes the likelihood of the data under H_1 compared to H_0, BF_{10} = 1/3–1/10, moderate evidence for H_0; BF_{10} = 1–1/3, anecdotal evidence for H_0, BF_{10} = 1–3, anecdotal evidence for H_1.

Narrative Scoring Scheme, $F(7, 49) = 3.04$, $p < 0.01$, partial $\eta^2 = 0.030$, Wilk's $\Lambda = 0.697$. There were statistically significant group differences in character development, mental, and emotional states and referencing/listener Awareness; with the ASD group performing worse than the control group. No group differences were found in the NSS subcategories introduction, conflict, cohesion, and conclusion. An additional ANOVA showed significant group differences in the NSS total score, $F(1, 55) = 7.72$, $p < 0.01$. Additional Bayesian statistics support the findings. The F, p, partial η^2 values and Bayes factors for each group effect are reported in Table 2.

Free imagery task

To investigate group differences in performance with regards to each subcomponent of the experiential index, we conducted one-way ANOVAs. No significant main effects of group were found. Bayesian statistics supported these findings (BF_{10} = 0.27–1.37). The F, p, Cohen's d for values for group effects and Bayes factors are reported in Table 3.

Guided imagery task

Several one-way ANOVAs were conducted to investigate group differences in performance in the guided imagery task. No significant main effects of group were found, neither with regards to external ratings nor participants' self-ratings. Bayesian statistics supported the null hypothesis (BF_{10} = 0.27–0.98). The ASD group ($M = 0.45$, SD = 0.42) recognized more spatial mistakes within the descriptions than the control group ($M = 0.14$, SD = 0.26), $F(1, 55) = 11.32$, $p < 0.001$. No difference between the ASD ($M = 0.40$, SD = 0.30) and the control group ($M = 0.30$, SD = 0.47) was found regarding the

TABLE 4 Mean (SD) external and participant rating of the guided imagery task.

	ASD ($n = 30$)	Controls ($n = 27$)				Bayesian ANOVA
	M (SD)	*M* (SD)	$F(1, 56)$	*p*	*d*	BF_{10} [a]
External Rating—Number of mentioned details (0–10)	3.48 (1.51)	3.51 (1.16)	0.05	0.832	0.06	0.27
Participant ratings						
Sense of presence (0–4)	2.62 (0.67)	2.94 (0.68)	3.15	0.081	0.47	0.98
Perceived salience (0–4)	2.37 (0.73)	2.65 (0.70)	2.33	0.133	0.41	0.70
Spatial coherence index (0–6)	2.92 (2.11)	3.93 (1.70)	2.58	0.114	0.43	0.78
Recognized mistakes (%)	0.44 (0.36)	0.16 (0.29)	10.78	0.000	0.33	19.21

Abbreviation: ASD, autism spectrum disorder.
[a] BF_{10} describes the likelihood of the data under H_1 compared to H_0, $BF_{10} = 1/3–1/10$, moderate evidence for H_0; $BF_{10} = 1–1/3$, anecdotal evidence for H_0, $BF_{10} = 1–3$, anecdotal evidence for H_1, $BF_{10} = 3–10$, moderate evidence for H_1, $BF_{10} = 10–30$ strong evidence for H_1.

recognition of the logical mistake, $p > 0.5$. The *F*, *p*, Cohen's *d* for values for group effects and Bayes factors are reported in Table 4.

Correlation analysis

Correlational analyses were conducted to explore the association between narrative task performance and the performance in the imagery tasks. The results for the ASD and the control group can be found in Tables 5 and 6, respectively.

DISCUSSION

Several studies have reported deficits in EFT in children (Hanson & Atance, 2014; Lind et al., 2014a; Marini et al., 2018; Terrett et al., 2013) and adults with ASD (Lind & Bowler, 2010; Lind et al., 2014b). To our knowledge, Lind et al.'s (2014b) study is the only study that linked EFT deficits in ASD to reduced scene construction ability (Hassabis & Maguire, 2007; Maguire & Mullally, 2013). However, previous studies may be somewhat limited by using tasks that may have disadvantaged participants with ASD due to their autistic characteristics such as weak central coherence (Joseph et al., 2009) or reduced communication abilities (American Psychiatric Association, 2013). During imagery tasks individuals with ASD may be focusing on single details of a scene, rather than imaging or describing it more globally which may result in an overall poorer performance. Impairments in communication could lead to autistic individuals not spontaneously mentioning specific details during imagery tasks when they are not explicitly requested to do so (e.g., Capps et al., 2000; Ganz & Flores, 2009; Losh & Capps, 2003).

Therefore, the aim of the present study was to reexamine scene construction ability in ASD while making sure to take such specific autistic characteristics (e.g., WCC) into account. To this end, a guided imagery task was provided next to the traditionally used free imagery task. In the guided imagery all elements for "binding a scene in mind" were given, ensuring that there was no uncertainty about the specific details of the objects that had to be included in the mental representation and less imagination was required.

Contrary to Lind and colleagues' results and our own expectations, the present study did not find any deficits in the free imagery of fictional scenes in adults with ASD. There were no differences in the quality of the imagined scenes between participants with and without ASD, neither with regards to participants' subjective self-ratings nor the ratings by the external raters. These findings contradict the results of earlier studies that investigated EFT in ASD (Hanson & Atance, 2014, Lind & Bowler, 2010; Lind et al., 2014b; Marini et al., 2018; Terrett et al., 2013). Importantly, in the present study participants were asked to imagine only fictional scenes, not past or future events which may underlie the differences in the results between this and previous studies that all required the imagination of one's personal future (EFT) and/or a past event (episodic memory). However, Lind et al. (2014b) reported poorer performance of the ASD group in all imagery tasks (episodic memory, EFT, and the imagining of fictional scenes) which implies general difficulties, although effect sizes were small in their study.

The contrasting finding of the present study could also be due to differences in the gender and age distribution of our samples as compared to previous studies. In contrast to other studies where most participants with ASD were men (e.g., Lind & Bowler, 2010; Lind et al., 2014b), more women with ASD participated in this study. This might be due to the fact that our participants were also recruited through social media. Women generally use social media more frequently than men (Perrin, 2015). Possibly, women with ASD may also have been more willing to participate in our online experiment than men. Research on the characteristics of women with ASD is still limited, but there is some evidence that females' symptomatology may differ from that of men (e.g., Ratto et al., 2018). For example, studies in *children* indicate that girls with ASD perform better in narrative tasks than boys with ASD (Conlon et al., 2019); at least

TABLE 5 Correlations of study variables in the ASD group.

	NSS								Free imagery task										Guided imagery task				Individual difference variables		
Variable	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
NSS																									
1. Introduction																									
2. Character development	0.39*																								
3. Mental and emotional states	0.39*	0.67**																							
4. Referencing/Listener awareness	0.34	0.42*	0.32																						
5. Conflict	0.46*	0.57**	0.74**	0.35																					
6. Cohesion	0.53**	0.45*	0.38*	0.24	0.65**																				
7. Conclusion	0.48**	0.08	0.19	0.18	0.11	0.12																			
8. Total Score	0.70**	0.75**	0.82**	0.57**	0.85**	0.71**	0.39*																		
Free imagery task																									
9. Experiential index score	0.60**	0.48**	0.57**	0.18	0.59**	0.48**	0.29	0.67**																	
10. Content total score	0.55**	0.41*	0.52**	0.13	0.53**	0.45*	0.17	0.59**	0.94**																
11. Spatial references	0.42*	0.09	0.11	−0.16	0.21	0.38	0.03	0.22	0.61**	0.73**															
12. Entities present	0.47**	0.28	0.45**	0.29	0.49**	0.25	0.24	0.52**	0.75**	0.79**	43*														
13. Sensory descriptions	0.44*	0.47**	0.62**	0.26	0.56**	0.49**	0.15	0.64**	0.76**	0.81**	0.30	0.65**													
14. Thoughts/emotions/ actions	0.39*	0.46	0.49**	0.14	0.46	0.23	0.17	0.49**	0.84**	0.81**	0.43*	0.53**	0.59**												
15. Rating of description quality	0.62	0.37	0.11	0.64	0.85	0.86	0.40	0.67	0.79	0.87	0.62	0.37	0.11	0.64											
16. Sense of presence	0.23	0.32	0.21	0.28	0.56	0.45	0.49	0.23	0.22	0.39	0.33	0.23	0.32	0.21	0.28										
17. Perceived salience	0.35	0.37	0.18	0.31	0.58	0.48	0.51	0.26	0.30	0.38	0.36	0.92	0.35	0.36	0.18	0.31									
18. Spatial coherence index	0.38	0.40	0.48	0.52	0.74	0.50	0.27	0.48	0.41	0.46	0.40	0.52	0.52	0.38	0.39	0.48	0.52								
Guided imagery task																									
19. Number of mentioned details	0.45	0.43	0.35	0.25	0.40	0.41	−0.01	0.47	0.67	0.72	0.60	0.52	0.52	0.61	0.68	0.22	0.20	0.30							
20. Sense of presence	0.67	0.18	0.33	−0.09	0.37	0.36	0.37	0.44	0.64	0.56	0.51	0.43	0.40	0.40	0.41	0.55	0.63	0.56	0.46						
21. Perceived salience	0.69	0.20	0.31	−0.00	0.37	0.29	0.38	0.44	0.64	0.51	0.44	0.47	0.31	0.41	0.37	0.61	0.67	0.60	0.39	0.94					
22. Spatial coherence index	0.56*	0.34	0.37*	0.21	0.48*	0.33	0.32	0.52**	0.66**	0.47**	0.22	0.49**	0.42*	0.40*	0.33	0.40*	0.44*	88**	0.34	0.53**	0.61**				
Individual difference variables																									
23. AQ-Total score	−0.11	−0.20	−0.27	−0.38*	−0.30	−0.03	−0.10	−0.29	−0.13	0.06	0.37	−0.08	−0.04	0.17	−0.17	−0.09	−0.05	−0.29	−0.10	−0.01	−0.17	−0.32			
24. FEA-ASB-Total Score	0.05	0.27	0.12	0.19	0.25	0.24	0.13	0.26	0.21	0.19	0.08	0.22	0.21	0.11	0.22	−0.01	0.00	0.10	0.14	0.09	−0.00	−0.02	0.17		
25. WAIS.IV-VA	−0.02	−0.10	0.18	−0.26	0.30	−0.00	−0.06	0.04	−0.12	−0.10	0.01	−0.02	−0.12	−0.17	−0.10	−0.04	0.08	−0.14	−0.14	0.06	0.04	−0.12	−0.22	0.10	
26. WAIS-IV-NVA	0.11	−0.23	−0.17	−0.06	0.14	0.21	−0.07	−0.02	0.07	0.17	0.38*	0.01	−0.02	0.07	−0.02	−0.00	0.11	−0.09	0.22	0.17	0.08	0.02	0.01	0.07	0.18

Note: *Indicates $p < 0.05$; ** indicates $p < 0.01$.
Abbreviations: ASD, autism spectrum disorder; WAIS-IV-VA, Wechsler Intelligence Scale verbal ability (vocabulary subtest); WAIS-IV-NVA, Wechsler Intelligence Scale non-verbal ability (matrices reasoning subtest).

TABLE 6 Correlations of study variables in the control group.

	NSS								Free imagery task										Guided imagery task				Individual difference variables		
Variable	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
NSS																									
1. Introduction																									
2. Character development	0.33																								
3. Mental and emotional states	0.41*	0.38																							
4. Referencing/Listener awareness	0.28	0.23	0.29																						
5. Conflict	0.61**	0.40*	0.86**	0.29																					
6. Cohesion	0.54**	0.61**	0.66**	0.29	0.79**																				
7. Conclusion	0.17	0.18	0.27	0.16	0.27	0.29																			
8. Total Score	0.64**	0.60**	0.84**	0.44*	0.90**	0.88**	0.50**																		
Free imagery task																									
9. Experiential index score	0.13	0.09	0.39*	0.04	0.29	0.17	0.02	0.26																	
10. Content total score	0.18	−0.00	0.46*	0.06	0.32	0.24	0.09	0.32	0.89**																
11. Spatial references	−0.01	0.02	0.27	−0.07	0.25	0.11	0.08	0.18	0.62**	0.67**															
12. Entities present	0.10	−0.21	−0.00	−0.21	0.00	0.09	0.13	0.01	0.45*	0.55**	0.41*														
13. Sensory descriptions	0.21	−0.02	0.46*	0.08	0.25	0.30	0.11	0.32	0.63**	0.82**	0.33	0.48*													
14. Thoughts/emotions/actions	0.15	0.10	0.36	0.21	0.27	0.10	−0.04	0.23	0.69**	0.64**	0.20	−0.04	0.32												
15. Rating of description quality	0.31	0.07	0.44*	0.22	0.33	0.30	0.19	0.39*	0.83**	0.88*	0.49**	0.43*	0.67**	0.73**											
16. Sense of presence	−0.16	0.11	0.07	−0.08	0.04	−0.06	0.01	−0.01	0.38	0.16	0.19	0.9	0.01	0.19	0.10										
17. Perceived salience	0.08	0.30	0.08	0.06	0.09	0.08	−0.05	0.11	0.40*	0.14	0.00	0.04	−0.04	0.35	0.17	0.81**									
18. Spatial coherence index	−0.23	0.12	0.03	−0.14	−0.01	−0.12	−0.24	−0.11	0.58**	0.22	0.32	0.06	0.01	0.23	0.12	0.41*	0.42*								
Guided imagery task																									
19. Number of mentioned details	0.18	−0.15	0.15	0.41*	0.26	0.14	0.32	0.26	−0.23	−0.18	−0.01	−0.16	−0.02	−0.24	−0.17	0.04	−0.13	−0.27							
20. Sense of presence	0.22	0.19	−0.19	0.00	−0.14	0.04	−0.15	−0.07	0.03	−0.26	−0.21	−0.18	−0.29	−0.03	−0.19	0.35	0.38*	0.38*	0.16						
21. Perceived salience	0.25	0.16	−0.04	−0.02	0.17	0.01	−0.05	0.07	0.14	−0.11	−0.11	−0.14	−0.18	0.08	−0.08	0.38	0.46	0.37	0.12	0.92					
22. Spatial coherence index	0.06	0.20	0.03	−0.06	0.17	0.04	−0.33	0.01	0.33	0.01	0.06	0.00	−0.20	0.20	−0.03	0.21	0.34	0.73**	−0.20	0.57**	0.54**				
Individual difference variables																									
23. AQ-Total score	−0.16	−0.06	0.04	−0.35	−0.00	0.06	0.13	−0.02	−0.01	−08	0.42*	0.20	−0.07	−0.17	−0.03	0.08	−0.09	−0.09	−0.03	−0.39*	−0.37	−0.27			
24. FEA-ASB-Total Score	−0.06	−0.03	0.07	−0.50**	0.21	0.16	0.10	0.06	−0.07	−0.07	−0.01	0.19	−0.20	−0.02	0.02	0.13	−0.01	−0.14	−0.08	0.03	0.10	0.04	0.35		
25. WAIS-VA	0.27	0.07	0.08	0.43	0.11	−0.14	0.07	0.12	0.20	0.13	0.09	−0.06	0.05	0.20	0.10	0.10	0.16	0.13	0.39	0.39	0.38	0.04	−0.25	−0.45	
26. WAIS-NVA	0.31	0.10	0.09	0.00	0.15	−0.11	−0.04	0.08	0.13	0.03	0.13	−0.11	−0.17	0.21	0.08	−0.09	−0.06	0.20	0.10	0.27	0.21	0.08	0.10	0.00	0.53

Note: *Indicates $p < 0.05$; ** indicates $p < 0.01$.

Abbreviations: ASD, autism spectrum disorder; WAIS-IV-VA, Wechsler Intelligence Scale verbal ability (vocabulary subtest); WAIS-IV-NVA, Wechsler Intelligence Scale non-verbal ability (matrices reasoning subtest).

with regards to verbalizing characters' internal states and emotions (Kauschke et al., 2016). Similarly, there is evidence in typically developing populations that girls without ASD produce more speech (Ely & McCabe, 1993) and more syntactic complexity in their narratives (Maines et al., 2002) than boys.

Hull et al. (2020) discussed in their review whether women with ASD might be more inclined to learn social rules and behaviors to better fit into society. This increased social drive (see also Dean et al., 2017 about social behaviors in girls with ASD) could lead women with ASD to exhibit less social avoidance (which seems to be common in ASD, see Spain et al., 2018) and to engage more frequently in various (social) contextual scenarios. For example, a woman with ASD might more often seek out scenarios like a shopping street in the city center and thus gather a wider range of information about the construction of such scenarios. Consequently, recalling an imaginative representation of such a scene might come more easily to her compared to someone who had less exposure or intentionally avoided such scenarios. Due to the insufficient evidence regarding the cognitive characteristics of women with ASD, this assumption is, of course, highly speculative at this point and more research directly measuring cognitive and symptomatic differences in women and men with autism is needed. The authors explained the advantage of women in imagination with evidence of lower default mode connectivity among males than among females (e.g., Tomasi & Volkow, 2012). Since our sample was predominantly composed of women with ASD, this could have affected the results in a way that, unlike the study by Lind et al. (2014b), no group differences were found between individuals with and without ASD. Therefore, the rather unusual gender distribution of our sample may have impacted our results in the narrative and imagery tasks.

In addition, many of the studies reporting deficits in EFT in ASD examined children (Hanson & Atance, 2014; Marini et al., 2018; Terrett et al., 2013), while the current study only included adult participants. Possible developmental deficits in specific cognitive functions, such as EFT, might be compensated across the lifespan (e.g., as a result of a general increase in knowledge and skills, as speculated in the previous paragraph regarding women with ASD), making a prediction of adult performance based on childhood findings unreliable. Conclusions about scene construction are further limited by the fact that most studies only examined EFT but not mental imagery in general.

As indicated earlier, narrative abilities are essential for the successful completion of imagery tasks given that participants have to tell the experimenter about their mental representations during imagery. Thus, narrative abilities inevitably affect imagery task performance, as participants' performance is assessed based on their oral descriptions. Findings from narrative studies indicate that participants with ASD might not mention specific details when they are not explicitly asked for those (cf. studies on narrative abilities, e.g., Capps et al., 2000; Ganz & Flores, 2009; Losh & Capps, 2003). This may negatively impact ASD participants' measured imagery task performance given that the request for a scene description is formulated rather unspecifically by the experimenter ("Describe your mental representation in as much detail as possible"). We chose the NSS to measure narrative abilities because its subdivision into various subscales provides a more nuanced understanding of participants' narrative skills and may allow for hypotheses about the type of details mentioned or omitted. However, the NSS also assesses broader skills such as character development and awareness of mental and emotional states and may thus measure abilities that go beyond the specific component narrative skills required for our experimental task. In contrast, the rating scheme (Norbury & Bishop, 2003; Reilly et al., 1998) used by Lind et al. (2014b) primarily focused on how many details participants provided and whether a global narrative structure was generated and may, therefore, represent a more suitable control task to assess whether participants are generally able to verbalize information.[1]

Moreover, the choice of the to be imagined scenes may have differed across studies and may have affected results. Unfortunately, previous studies did not provide full information on the to be imagined scenes and only gave some examples of the scenes that were used. We based our scenes on these examples, but due to the lacking information could not use exactly the same scenes as other studies (e.g., Hassabis & Maguire, 2007; Lind et al., 2014b). Evidence for the possible (negative) impact of specific to be imagined scenes on performance came from a strikingly large number (25%–30%) of ASD participants in our study who described, for example, that they experienced the imagination of the railway station or the supermarket as very aversive because of the many, typically present, sensory stimuli. Sensory processing problems in ASD are frequently reported in the literature (Ben-Sasson et al., 2009). Research in non-autistic population has shown that higher anxiety is associated with greater EFT details/vividness when negatively-valenced cues are provided (Du et al., 2022). Therefore, it is possible that emotional distress, for example, induced by the vivid imagination of an aversive event, might have led to increased imagination of details and thus higher imagery scores in our ASD sample.

Furthermore, a considerable number of participants with ASD exhibited comorbid affective disorders, primarily depression and anxiety disorders. However, only a small number in the control group did so. Indeed, depression and anxiety disorders are also believed to be characterized by mental imagery dysfunctions and alterations (e.g., Hirsch & Holmes, 2007; Holmes et al., 2016).

[1]We thank an anonymous reviewer for this suggestion.

Therefore, it is possible that the presence of comorbid disorders affected participants abilities to engage in imagery tasks. Finally, the ASD group seemed to be more motivated to take part in this study than the control group which could have positively affected their performance.

Regarding the guided imagery task which comprised predefined scene descriptions, we expected to find no differences with regards to the quality of the reports between the groups, as these, in comparison to free imagery, would not require the independent development of scene descriptions by participants. In line with our expectations, the quality of the reproduction of the specified scenes was comparable between groups. Participants with ASD reported as many details in their descriptions as participants in the control group. Furthermore, there were no group differences in the self-assessment of the quality of the descriptions.

To obtain further evidence of participants' scene construction ability, we also included spatial reasoning errors in the descriptions. Interestingly, participants with ASD detected significantly more of these errors than controls. However, no group differences were found with regards to logical errors. Possibly, participants with ASD found it easier to imagine spatially coherent scenes than control participants, as they recognized spatial errors with greater accuracy. Importantly, we conducted only four trials in the guided imagery task, resulting in a total of three spatial mistakes but only one logical one to detect. Given the limited number of trials, future research could potentially replicate the task with a higher number of trials, including repetitions without embedded mistakes, in order to gather more robust evidence.

To ensure that impairments in narrative abilities were not responsible for possible deficits in scene construction, participants also completed a narrative task. Participants with ASD showed worse narrative performance than non-ASD controls. The ASD group performed poorer in the NSS subcategories of character development, mental and emotional states as well as referencing/listener awareness than the control group. Previous evidence on the narrative ability in ASD is mixed (see Baixauli et al., 2016 for a meta-analysis on narrative abilities in children with ASD). There is evidence for a reduced use of referential expressions as character descriptions (Colle et al., 2008; Norbury & Bishop, 2003) and the expression of mental and affective states (Capps et al., 2000; Rollins, 2014; Siller et al., 2014). Possibly, the detail-oriented processing style in ASD (weak coherence, Happé et al., 2001, Happe & Frith, 2006) led them to emphasize other aspects of the story (e.g., description of the scene) than characters descriptions. This could also have resulted in a diminished listener awareness, as disregarding characters' inner world and interaction with the environment may make the story more static and less evolving. In fact, in the present study ASD participants seemed more inclined to give accurate descriptions of the pictures shown on the single book pages than to refer to the actions of the story characters. Certainly, the well-documented ToM deficits in ASD (e.g., Baron-Cohen et al., 1985) could have played a role here. However, the comparable performance to the control group in the other subcategories of the NSS (e.g., introduction, conflict, cohesion, and conclusion) suggests that overall, the told story did not lack cohesion as demonstrated in other studies (Colle et al., 2008; Diehl et al., 2006; Ferretti et al., 2018). Importantly, the subscales of the NSS in which participants with ASD scored lower were those that required imaginative abilities the most, for example, character descriptions or mental and affective states. The capacity for mentalization was involved here and along with that, the ability to make statements based on own prior knowledge. Unlike tasks such as describing a scene from a book, these tasks relied more on personal interpretation and prediction, rather than solely on the information provided by the pictures of the book.

Our free imagery task closely following Lind et al.'s (2014b) study also required a significant level of imaginative abilities. In this task, participants were asked to construct mental scenarios based on their personal knowledge of different locations. In contrast, our guided imagery task provided a detailed scene for participants to mentally engage with, limiting their freedom to shape the scene according to their own imagination. Therefore, we assume that the guided imagery task focused more on recoding given verbal information into mental images (one may define as imagery) rather than the ability of filling information gaps by forming new mental constructions that rely less on processing external stimuli and more on one's own fantasy (one may define as imagination) (see also Arcangeli, 2020; Gregory, 2010; Vecchi, 2018 on the differences between imagination and mental imagery). The fact that both the free imagery task and parts of the narrative task heavily rely on imagination could potentially explain the positive correlations we found between these tasks in the ASD group but not in the control group. If there is a shift in the balance between attention to details and influence of context and prior knowledge in ASD as suggested by predictive coding theory, this could possibly explain the deficits in imagination observed in ASD (see Crespi et al., 2016), even though their ability for imagery itself might be intact or even overdeveloped (Kana et al., 2006; Scott & Baron-Cohen, 1996; Soulières et al., 2011). This explanation is, of course, purely speculative, as we did not find any group differences in both the free and guided imagery task. Given that there is a broad variety within the autism spectrum in terms of the range and severity of individual symptoms, it is possible that the ability to rely on prior knowledge or heuristics and weigh them over details of the sensory input, might also vary on an individual level (Van des Cruys et al., 2014). Our sample differs from comparable studies primarily in the large proportion of women with ASD. Exploratory analyses suggest that there might indeed be a gender difference in the imagery tasks within the ASD group only.[2] Future studies should investigate whether women with ASD might lean toward a higher emphasis on prior knowledge or increased use of heuristics compared to processing situational cues, considering the fact, that women may have a greater inclination to fit into society (Hull et al., 2020), and, consequently, may accumulate more experiential knowledge. Exploring the role of gender and its potential interaction with imaginative abilities could provide valuable insights into the variability within the ASD population. Future research should also consider the formulation of task instructions, particularly in terms of which imagination constructs are being defined and assessed as well as the potential challenges that autistic characteristics might present in task comprehension and completion.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

This study gained ethical approval from the Research Ethics Committee at the Department of Psychology, Johannes Gutenberg-University Mainz, Germany.

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[2]Following the suggestion of an anonymous reviewer, we conducted exploratory analyses on gender differences within the experimental groups. The results can be found in Table S7 in the appendix.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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