Episodic future thinking and narrative discourse generation in children with Autism Spectrum Disorders

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ABSTRACT

Individuals with Autism spectrum disorders (ASD) have difficulties in the recollection of past experiences (Episodic Memory). Accumulating evidence suggests that they might have also difficulties in the ability to imagine potential future scenarios (Episodic Future Thinking, EFT) and in narrative generation skills. This investigation aimed to determine 1) whether impairments of EFT can be identified in a large cohort of children with high functioning ASD using a task with minimal narrative demands; and 2) if such impairments are related to the ability to generate a narrative's scenario. 77 children with high-functioning ASD and 77 children with typical development were recruited for the study. The two groups were balanced for age, level of formal education, and IQ. EFT was assessed by administering a task with minimal narrative demands, whereas narrative generation skills were assessed with three tasks requiring children to generate past, middle or future episodes in a narrative discourse. With respect to control participants, a subgroup of children with ASD had impaired EFT skills and also showed significant impairments in the ability to generate adequate narratives. On the contrary, participants with spared EFT had normal performance on the narrative generation task. Interestingly, EFT skills predicted narrative generation abilities in both groups. The results of this study support the hypothesis that EFT may be impaired in some but not all children with ASD and of a relation between difficulties with EFT and impairments in the process of narrative generation. The assessment of EFT should employ tasks that do not require narrative production, as children with impaired EFT may also have reduced narrative skills.

1. Introduction

Accumulating evidence suggests that individuals with Autism Spectrum Disorders (ASD) have difficulties in the ability to mentally travel through time (i.e., Mental Time Travel, MTT; Suddendorf & Corballis, 1997, 2007). This is a complex cognitive skill, which involves the ability to recollect past experiences (Episodic Memory, EM; Tulving, 1972) and foresee potential novel situations

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(Episodic Future Thinking, EFT; Atance & O'Neill, 2001). A number of neuropsychological and neuroimaging studies suggest that EM and EFT share important commonalities. For example, patients with impairments in EM have also difficulties in EFT (e.g., Klein, Loftus, & Kihlstrom, 2002). Similarly, even in healthy individuals both remembering the past and envisioning the future are implemented in a complex neural network with shared epicenters in medial temporal and frontal lobes, lateral parietal and temporal areas, bilateral hippocampi, the posterior cingulate and the retrosplenial cortex (Addis, Pan, Vu, Laiser, & Schacter, 2009, 2007; Buckner & Carroll, 2007; Hassabis, Kumaran, & Maguire, 2007; Martin, Schacter, Corballis, & Addis, 2011). As a final remark, growing evidence suggests that EM and EFT emerge in tandem between 3 and 5 years of age (Atance & Meltzoff, 2005; Atance & Sommerville, 2014; Busby & Suddendorf, 2005; Hayne, Gross, McNamee, Fitzgibbon, & Tustin, 2011; Scarf, Gross, Colombo, & Hayne, 2013).

Difficulties recalling past events of their lives have been frequently reported in individuals with ASD (Gaigg, Bowler, & Gardiner, 2014). For example, in Goddard, Howlin, Dritschel, and Patel (2007) participants were asked to generate memories of specific autobiographical events in response to cue words. Individuals with ASD recalled significantly fewer autobiographical memories and took longer to do so than did a control group. More recently, some studies have begun exploring their ability to imagine potential future scenarios (Hanson & Atance, 2014; Lind, Bowler, & Raber, 2014; Marini et al., 2016; Terrett et al., 2013). For example, Terrett et al. (2013) asked 30 children with ASD and 30 peers with typical development (TD) aged 8–12 years to describe personal past events and plausible future ones. As expected, the participants with ASD had more difficulties in remembering past events. However, they were also less able to imagine future scenarios. Interestingly, both groups were better at remembering past events than imagining future ones. This suggests that, even if related to each other and the expression of a common process of *episodic thinking* centered on mental travel from a self-oriented perspective (Buckner & Carroll, 2007), EM and EFT might also rely on partially different skills. This possibility has been further supported by studies showing that the generation of future episodes requires additional verbal working memory resources compared to the reconstruction of past events from EM (Hill & Emery, 2013). More recently, in Marini et al. (2016) children with ASD showed impaired performance on tasks requiring them to project themselves into a plausible future scenario. Interestingly, they had difficulties also in tasks requiring them to predict the outcome of a physical transformation which did not imply any projection of the Self. This suggests that impairments of EFT in ASD may not be limited to the projection of the Self. Nonetheless, the available studies have usually focused on Self-based EFT. In a study with a different design, Crane, Lind, and Bowler (2013) failed to find any group-related difference between 18 adults with ASD and 18 neurotypical participants on a sentence completion task requiring participants to generate past and future event descriptions. According to the authors, this finding might have been biased by the particular methodology used in their study and supports the need for the development of accurate measures of EFT and EM.

Overall, these results are still far from conclusive. The few available investigations often included a limited number of participants and this drastically limits their statistical power and the generalizability of their results. An additional problem is that the performance of the participants with ASD has not always been compared to that of adequately matched groups of control individuals. Together with the use of different methodologies, these limitations do not allow to gather sufficient information to make a firm point about the presence of EFT difficulties in ASD. Let's consider the lack of significant differences between participants with ASD and neurotypical individuals in the study by Crane et al. (2013). As already mentioned, the authors interpreted their negative result as a methodological bias. However, it is also possible that the group-related differences in performance did not reach statistical significance because of the inclusion of a heterogeneous group of participants with ASD (as highlighted by the fact that the standard deviations were higher for the ASD than for the control group). Indeed, at least some of them might have not experienced difficulties with EFT. As some studies highlighted impairments in EFT (e.g., Marini et al., 2016; Terrett et al., 2013), whereas others failed to find such difficulties (as shown in Crane et al., 2013), we hypothesize that impairments of EFT may not be a core feature of all persons with ASD. Appropriate tasks for the assessment of EFT might allow both clinicians and researchers to identify those individuals with ASD who have preserved or impaired EFT skills. Procedures based on interviews about past or future events might not be a good choice, as micro- (e.g., lexical, grammatical) and/or macrolinguistic (e.g., pragmatic, discourse level) difficulties, usually observed in ASD even if at different degrees (Boucher, 2012), might undermine their ability to deal with such tasks. A potential solution to this clinical problem comes from a study by Hanson and Atance (2014) who asked 25 children with ASD aged 3–8 years and 25 mental age-matched children with TD aged 3 to almost 6 years to complete five tasks assessing EFT. Although the authors declared that significant group-related differences were found for several of these tasks, a more careful statistical approach adopting a Bonferroni correction for multiple comparisons (0.05/the scores obtained on the 5 EFT tasks = 0.01) suggests that the only test where the participants with ASD scored significantly worse than the control group was the *Picture Book Trip* task (p < 0.005) by Atance and Meltzoff (2005) which involves the use of a measure for EFT with minimal narrative demands (see also Ferretti et al., b, 2018a).

The need to use a measure with minimal narrative demands for the assessment of EFT leads us to a second issue, i.e., the potential relation between difficulties in EFT and difficulties in comprehending (e.g., Jolliffe & Baron-Cohen, 2000) and generating coherently organized narratives (e.g., Ferretti et al., 2018a; Barnes & Baron-Cohen, 2012; Diehl, Bennetto, & Young, 2006; Sah & Torng, 2015; for a review, see; Stirling, Douglas, Leekam, & Carey, 2014). For example, in a study focusing on story recall and narrative coherence, Diehl et al. (2006) showed that 17 children with high-functioning ASD produced significantly less coherent narratives than 17 peers with typical development matched on age, gender, language, and cognitive abilities. Such difficulties have been related to 1) problems in managing the causal relations among the events of a story (King, Dockrell, & Stuart, 2014, 2013; Losh & Capps, 2003; Sah & Torng, 2015), 2) difficulties in the ability to manage social interactions – the Theory of Mind account (Baron-Cohen, Leslie, & Frith, 1986), or 3) difficulties in focusing on details without being able to integrate them into a wider global context – the Weak Central Coherence account (Jolliffe & Baron-Cohen, 2000; Nuske & Bavin, 2011). A potential alternative, recently suggested by Ferretti et al. (2018a) and further developed in the current study, is that a difficulty in the generation of coherent narratives in ASD might be

related to difficulties in EFT. This hypothesis is based on two basic assumptions. The former is that narrative processing requires a detachment from the actual moment in which the story is being processed (Corballis, 2015). The latter stems from the narratological tradition inspired by the work of Genette (1972/80) who highlighted the intrinsically temporal nature of narratives (see also Herman, 2013; Storey, 1996). Therefore, the ability to generate stories might rely at least in part on the same processes that allow individuals to reconstruct past episodes or to generate potential future ones (Corballis, 2011; Ferretti, 2016). Indeed, increasing evidence suggests that the two components of mental time travel (i.e., EFT and EM) are involved in the construction of personal past and future events as well as in the ability to envision past and future experiences of others (e.g., Buckner & Carroll, 2007; Hassabis et al., 2014; Payne, Taylor, Hayne, & Scarf, 2015). This further supports the hypothesis that EFT is involved in the construction not only of personal narratives, but also of narratives that are detached from any personal experience and involve events of others (both fictitious and real). In a recent investigation, Ferretti et al. (2018a) explicitly analyzed the relation between EFT and the ability to generate an adequate narrative micro- and macrostructure by establishing causal and global coherence links in ASD. They employed two narrative production tasks that required children to produce either future or past episodes with respect to target stimuli. The narratives produced by 66 children with ASD and 66 peers with typical development were compared. Interestingly, a subgroup of children with ASD who scored lower than expected on the *Picture Book Trip* task (considered as a measure of impaired EFT skills) produced more elements included in the target pictures, fewer new elements and causal links than ASD children who performed normally on the *Picture Book Trip* task and controls with typical development. This suggests that they were not able to detach themselves from the events portrayed in the target picture and to establish adequate microstructural links between the generated propositions. Interestingly, only those participants with ASD who performed lower on the *Picture Book Trip* task also produced more errors of global coherence than controls whereas those who scored normally on the same task produced as many errors of global coherence as controls with typical development. This suggests that those children with ASD who had impaired EFT could not generate adequate macrostructural links among the episodes they were generating. While supporting the idea of a relation between EFT and the ability to establish links among utterances at the micro- and macrostructural level, this study did not explicitly explore the possibility that EFT is necessary for the process of mental scene construction (see Hassabis et al (2007)) that is required to generate a mental model or scenario which will eventually trigger the macro- and microstructural organization of the narrative discourse. Following Hassabis et al (2007) scene construction can be conceived as "the process of mentally generating and maintaining a complex and coherent scene or event" (p. 299). Indeed, according to the influential Structure Building Framework (SBF; Gernsbacher, 1990), originally proposed to outline processes of discourse comprehension but that has been applied also to interpret discourse production deficits in patients with communicative impairments (Coelho et al., 2013; Gernsbacher, Tallent, & Bollinger, 1999; Marini, Zettin, Bencich, Bosco, & Galetto, 2017), a critical role in the process of discourse production is likely played by a prelinguistic conceptual phase where the speaker, through a process of foundation laying (which likely involves also scene construction), generates a structure or mental depiction of the story that will serve as a foundation for its development. In our opinion, the role of EFT, as a potentially critical contributor to this preliminary phase of narrative discourse generation, should be further explored.

Coherently with these premises, the current investigation aimed at exploring further the relation between EFT and narrative generation skills in large sample of 77 participants with high-functioning ASD. More precisely, this study focused on their ability to generate adequate mental models/scenarios on past-, middle-, and future-narrative production tasks in children with high-functioning ASD. We hypothesized that EFT would be a significant predictor of the ability to generate a narrative's future episodes (i.e., its conclusion), past episodes (i.e., its antecedent), or its actual development. Furthermore, coherently with the findings by Ferretti et al. (2018a), we also hypothesized that a subgroup of ASD children with impaired EFT skills (as assessed by administering the *Picture Book Trip* task by Atance and Meltzoff [2005]) would show greater difficulties in the ability to generate past, future and middle episodes in a narrative production task than a subgroup of ASD children with normal EFT skills and a group of children with typical development.

2. Methods

2.1. Participants

154 Italian-speaking children aged between 6 and 11.11 years was recruited for this study. They formed two groups with comparable chronological age ($t_{(152)}$ = .50; p = .628), level of formal education ($t_{(152)}$ = .43; p = .668), and IQ ($t_{(152)}$ = .15; p = .909) but different gender distribution [$X^2_{(1, N=154)}$ = 13.923, p < 0.001] (see Table 1). 132 of these participants participated in a former study (Ferretti et al., 2018a). The first group was formed by 77 children with high functioning ASD and IQ level (as measured with the Raven's Colored Progressive Matrices; Raven, 1938) in the normal range. The gravity of their symptomatology was assessed by administering the Autism Diagnostic Observation Schedule, 2nd edition - ADOS-2 by Lord et al. (2013). Overall, the group of participants with ASD had a mean gravity score of 6.12 with a standard deviation of 1.73 ranging from 2 to 9. Two of them (2.6%) had a score of 2 (minimal severity); 11 (14.3%) scored between 3 and 4 (low severity); 45 (58.4%) scored between 5 and 7 (moderate severity); 18 (23.4%) scored between 8 and 9 (high severity). The control group was formed by 77 children with typical development (TD). All of them performed within normal range at the Raven's Matrices, on the Non-Word Repetition subtest of the PROMEA scale (Vicari, 2007), and at the forward and backward digit span's subtests of the Wechsler Intelligence Scales for Children (Wechsler, 1993). According to school records and parents' reports none of them had a known history of psychiatric or neurological disorders, learning disabilities, hearing or visual loss. Parents released their informed consent to the participation of their children to the study and to the treatment of the data.

Table 1

General data of the two groups of participants. Data are expressed as means, standard deviations, ranges, frequencies and percentages where appropriate. *Legend*: ASD: (children with) Autism Spectrum Disorders; TD: (children with) Typical development; ADOS-2: Autism Diagnostic Observation Schedule 2nd Edition. Asterisks show when group-related differences were significant.

General Information	ASD (N = 77)			TD (N = 77)		
	M	(SD)	Min-Max	M	(SD)	Min-Max
Age	8.11	(1.51)	[6.00–11.09]	8.23	(1.51)	[6.00–11.11]
Education	3.0	(1.42)	[1st-5th grade]	3.08	(1.34)	[1st-5th grade]
IQ Level*	106.08	(14.13)	[80–141]	106.32	(11.41)	[90–130]
ADOS-2 Gravity Index	6.12	(1.73)	[2–9]	–		
	Frequency		Percent	Frequency		Percent
Sex*						
Males	70		90.9	51		66.20
Females	7		9.1	26		33.80

2.2. Materials and methods

The participants with TD were tested individually at school. Children with diagnosis of ASD were tested at Bambin Gesù Hospital in Rome. Children with typical development were assessed at their schools. Both groups of participants were administered the tasks in a quiet room in order to reduce elements of distraction during the administration procedure. The tasks included a cognitive assessment focusing on phonological short-term and working memory, episodic future thinking skills, and narrative generation abilities. The reason for the inclusion of tasks assessing phonological short-term and working memory relies in the important role played by these functions in performing the selected tasks. The order of presentation of the tasks was counterbalanced across participants.

2.2.1. Assessment of phonological short-term and working memory

All participants received three tests assessing their phonological short-term and working memory (two simple span tasks: the forward digit recall subtest of the Wechsler Scales, and the Non-Word Repetition Task of the PROMEA; one complex span task: the backward digit recall subtest of the Wechsler Scales. In the forward digit recall task, participants were required to repeat a list of spoken sequences ranging from 1 to 9 digits that the examiner had produced at the rate of 1 digit per second. The backward digit recall test is identical to the forward digit recall task, but the child was asked to repeat the sequence of spoken digits in reverse order. In the non-word repetition task, children were asked to repeat a total of 40 invented words following the phonotactic rules of Italian. A repetition was considered correct if the child had appropriately reproduced all the vowels and consonants in the item.

2.2.2. Assessment of EFT: the Picture Book Trip task

In the *Picture Book Trip task* (Atance & Meltzoff, 2005) each child was shown, one at a time, 4 colored pictures illustrating different destinations for a trip: a waterfall, a sandy desert with a long road, a mountain view, and a rocky stream. They were asked to describe each picture's contents, and then were explicitly asked to imagine themselves in the scenarios at a future time point. For each of the four target pictures (e.g., *waterfall*), the experimenter showed three different photographs, each representing a specific item that could be: 1) useful in the target scenario (i.e., *watercoat*); 2) completely useless in that scenario and not related to the scene (i.e., *money*), 3) semantically primed by the scenario (i.e., *rocks*). Children were asked which of these items they would need to bring with themselves. After choosing the selected item, they were invited to motivate their answers, explaining how the selected item would be useful in that scenario anticipating potential future needs ("Which of the objects portrayed in these pictures will you need to take with you in this trip?" and then: "Why will you need this in your trip?"). Children received 1 point for each item that had been correctly chosen (Identification Score, IS). One additional point was assigned whenever they could adequately motivate their choice showing that they had been able to project themselves to meet a potential future need (Motivation Score, MS). Noteworthy, in the original version of the task, the Motivation Score was derived from a linguistic analysis of the motivation produced by the child for his/her choice. The child received 1 point only if (s)he included in the motivation 1) a future term (e.g., *going to*, *will*, *when*) and 2) words that explicitly referred to internal feelings. However, in Italian future states can be expressed also with present tense (e.g., "Domani vado a casa" "*Tomorrow, I go home*"). For this reason, in our study, in order to avoid a potential linguistic bias, the motivation received 1 point if it correctly explained the choice regardless of the linguistic form used by the child. An EFT Composite Score was derived by summing up these two scores (max 8).

2.2.3. Assessment of narrative generation skills

The ability to generate adequate mental models in the process of narrative generation was assessed by administering three cartoon-story description conditions. Three cartoon-stories (one trial and two targets) were designed to assess the children's ability to generate a future episode in a narrative discourse (i.e., its conclusion). Three (one trial and two targets) were used to assess their ability to generate a past episode (i.e., its antecedent). The remaining three (one trial and two targets) were used to assess their ability

to adequately generate a narrative linking the beginning of a story with its ending by adding relevant and coherent pieces of information about its development (i.e., its development). For each condition, the first cartoon-story was used as trial in order to allow children to get acquainted with the test.

In the future-generation condition, the experimenter arranged three sheets of paper on the table: the first two sheets contained colored drawings that portrayed the beginning of a story, while the third was blank. The experimenter begun by describing the first picture (e.g., "Here is Mr. Mario. He is whistling as he walks down this road."). (S)he then asked the child to describe the second picture (e.g., "Mr. Mario fell down an open manhole."). While pointing at the blank sheet, the experimenter eventually asked the child to continue with the story by asking him/her: "What will happen now?". For each story, children were left free to talk until they came to an end. In case they did not finish the story, the examiners prompted them only once with a standardized question: "And then?".

In the past-generation task, for each child the experimenter arranged two sheets on the desk. Of these, the former was blank but the second contained a colored sketch. While pointing at it, the experimenter described the scene depicted in the drawing (e.g., "There is a family in a garden with a dog wash tub and soapy water everywhere. Dad and son are wet and angry. Mom and daughter look at them amused. Their dog stares at the scene"). While pointing at the blank sheet, the experimenter eventually asked the child to describe what could have likely happened earlier in this story by asking "What happened earlier?". Also in this case for each story children were left free to talk until they felt that they had said all about the beginning of these stories. In case they did not finish the story, the examiners prompted them only once with a standardized question: "And then?".

In the middle-generation task, for each child the experimenter arranged three sheets of paper on the table: one sheet contained a colored drawing that portrayed the beginning of a story, a second sheet was blank and a third sheet depicted the end of the story. The experimenter described the first picture (e.g., "It's early in the morning. Marco and Giulia, his sister, wake up. Chappy, their dog, is still sleeping close to their beds"). (S)he then described the picture contained in the third sheet. While pointing at the blank sheet, the experimenter eventually asked the child to produce a sample of narrative language that could link the first scene with the third by asking him/her: "What happened in the middle of the story?". For each story, the children were left free to talk until they came to an end. In case they did not finish the story, the examiners prompted them only once with a standardized question: "And then?".

In order to avoid poor performance due to short-term memory limitations, all pictures remained visible until the subjects had finished their descriptions. Each story was tape-recorded and subsequently transcribed verbatim. For all tasks, only the narrative samples produced by the child when the experimenter pointed at the blank sheets were included in the analyses. Each narrative received 0 (absence of the ability to generate a mental model or scenario and introduce any new story element), 1 (ability to introduce a new story element and therefore generate a minimal mental model or scenario) or 2 (ability to introduce two or more new story elements and further elaborate on the story) points. A narrative received 0 points if the child had been unable to introduce any new element in the story or introduced elements that were not causally connected with the initial stimulus. A story received 1 point if (s)he introduced just one new element a) not included in the image stimulus and b) causally and temporally connected with it (e.g., (s)he produced just one sentence or a few utterances that could be abruptly interrupted or contained only one relevant piece of information together with tangential, filler or repetitive comments). Finally, a story received 2 points if the child had been able to further elaborate on its contents by producing a comprehensive narrative with the inclusion of several pertinent and relevant pieces of information. This allowed us to derive a Future-Narrative Generation Index (F NGI), a Middle-Narrative Generation Index (M NGI), and a Past-Narrative Generation Index (P NGI). The F NGI for each child was calculated by summing up the scores obtained by his/her stories in the future generation task (maximum score: 4). The M NGI for each child was calculated by summing up the scores obtained by his/her stories in the middle generation task (maximum score: 4). Similarly, the P NGI for each child was calculated by summing up the scores obtained by his/her stories in the past generation task (maximum score: 4). These three scores were eventually summed to obtain a Narrative Generation Index (NGI) reflecting the children's ability to adequately project in the stories by producing coherent and appropriate pieces of information in a narrative discourse (maximum score: 12).

The scoring procedure was performed independently by two trained raters on the narratives produced by the participants. The level of inter-rater reliability was analyzed by performing kappa statistics. This analysis confirmed the presence of a substantial inter-rater agreement for the Narrative Generation Index (K = 0.730; p < .001). This agreement was even higher for the Future- (K = 0.820; p < .001), Middle- (K = 0.889; p < .001) and Past- (K = 0.886; p < .001) Narrative Generation Indices.

3. Results

3.1. Analysis of phonological short-term and working memory skills of the two groups

Before exploring potential group-related differences on the three measures assessing phonological short-term and working memory, preliminary analyses assessing homogeneity of variance were run. The Levene's test for equality of variances showed that the assumption of homogeneity of variance had not been violated for the Forward Digit Span subtest of the WISC. However, this preliminary analysis showed that such assumption had been violated for the Backward Digit Span Task (p < 0.001) and the performance at the Non-Word Repetition subtest (p < 0.003). For this reason, one independent-sample t-test was with Group (ASD vs. TD) as fixed factor and the scores obtained on the Forward Digit Span task as dependent variable. For the remaining two variables, potential group-related differences were analyzed by performing two separate Mann-Whitney tests with Group (i.e., ASD vs TD) as independent factor and the scores obtained by the participants at the Backward Digit Span task and at the Non-Word Repetition Task as dependent variables. The level of statistical significance was set at p < 0.017 (0.05/3 dependent variables) after Bonferroni correction for multiple comparisons. As shown in Table 2, the two groups differed on their performance at the Forward Digit Span

Table 2

Phonological short-term and working memory in the two groups of participants. Data are expressed as means, standard deviations, and ranges. *Legend*: ASD: (children with) Autism Spectrum Disorders; TD: (children with) Typical development. Asterisks (*) show when group-related differences were significant after Bonferroni correction for multiple comparisons (p < .017).

	ASD			TD			Effect size
	M	(SD)	[Min-Max]	M	(SD)	[Min-Max]	
Digit Forward*	5.79	(1.40)	[3–10]	6.95	(1.54)	[3–10]	0.79
Digit Backward	3.53	(1.66)	[0–8]	3.96	(1.22)	[2–7]	0.16
Non-Word Repetition	32.95	(5.80)	[6–40]	33.96	(3.42)	[25–40]	0.03

subtest of the WISC ($t_{(150)} = 4.87$; p < 0.001; Cohen's d = 0.79) but performed similarly at the Backward Digit Span subtest of the WISC ($Z = -2.03$; p = 0.04; r = -0.16) and at the Non-Word Repetition subtest of the PROMEA ($Z = -0.34$; p = 0.74; r = -0.03).

3.2. Analysis of episodic thinking skills in children with ASD and children with TD

As the two groups differed on their performance at the Forward Digit Span subtest of the WISC, we aimed to assess the presence of group-related differences on EFT considering the potentially confounding role of phonological short-term memory. The relationship between performance at the Forward Digit Span task and the measures of EFT and narrative generation was investigated using Pearson product-moment correlation coefficient on the whole sample of participants. Significant positive correlations were found between the Forward Digit Span scores and both the Episodic Future Thinking Score (r = 0.358; p < 0.001) and the Narrative Generation Index (r = 0.437; p < 0.001). A further analysis was performed to control for potential significant correlations also between the Forward Digit Span scores and the three separate indices of narrative generation. These analyses confirmed that this measure of phonological short-term memory correlated with all of them: F NGI (r = 0.396; p < 0.001), M NGI (r = 0.366; p < 0.001), and P NGI (r = 0.373; p < 0.001). For this reason, the group-related differences on the assessment of the participants' EFT skills and the Narrative generation skills were analyzed by performing two ANCOVAs with group (i.e., ASD vs. TD) as fixed factor, the Episodic Future Thinking Score and the Narrative Generation Index as dependent variables, and the participants' performance at the Forward Digit Span subtest of the WISC as covariate. The level of statistical significance was set at p < 0.025 (.05/2 dependent variables) after Bonferroni correction for multiple comparisons (see Table 3). The analysis revealed that the participants with ASD scored significantly lower than children with TD in the measure assessing EFT ([$F (1, 149) = 28.57$, p < 0.001, $\eta_p^2 = 0.161$) and in the Narrative Generation Index ([$F (1, 149) = 20.33$, p < 0.001, $\eta_p^2 = 0.120$).

In order to further explore potential group-related differences in any of the three narrative generation indices, an additional series of ANCOVAs with group (i.e., ASD vs. TD) as fixed factor, the three narrative generation indices (Future-, Middle-, and Past-Narrative Generation Index) as dependent variables and the participants' performance at the Forward Digit Span subtest of the WISC as covariate. The level of statistical significance was set at p < 0.017 (0.05/3 dependent variables) after Bonferroni correction for multiple comparisons (see Table 3). These analyses confirmed the presence of significant group-related differences in the Future-Narrative Generation Index ([$F (1, 149) = 23.87$, p < 0.001, $\eta_p^2 = 0.138$) and in the Past-Narrative Generation Index ([$F (1, 149) = 13.30$, p < 0.001, $\eta_p^2 = 0.082$) but not in the Middle-Narrative Generation Index ([$F (1, 149) = 5.40$, p = 0.022, $\eta_p^2 = 0.036$).

The relationship between performance at the task assessing EFT and the Narrative Generation Index was first investigated separately in the two groups using Pearson product-moment correlation coefficient. This preliminary analysis showed that such measures were significantly correlated for both children with ASD (r = 0.61; p < 0.001) and participants with TD (r = 0.29; p < 0.006). A simple linear regression analysis was then conducted to test if scores at the Trip Destination task significantly predicted the participants' Narrative Generation Index in both groups. Using the enter method, for participants with ASD the predictor

Table 3

Performance of the two groups on tasks assessing their Episodic Future Thinking skills and their Future-, Middle- and Past-Narrative Generation Indices. Data are expressed as means, standard deviations, and ranges. *Legend*: ASD: (children with) Autism Spectrum Disorders; TD: (children with) Typical development.

	ASD			TD			Effect size
	M	(SD)	[Min-Max]	M	(SD)	[Min-Max]	
Episodic Future Thinking Score*	5.12	(2.17)	[0–8]	7.04	(1.25)	[5–8]	0.16
Narrative Generation Index*	6.60	(3.59)	[0–12]	9.47	(2.00)	[4–12]	0.12
Future-Narrative Generation Index*	2.38	(1.40)	[0–4]	3.49	(.67)	[2–4]	0.14
Middle-Narrative Generation Index	2.07	(1.26)	[0–4]	2.78	(1.08)	[0–4]	0.04
Past-Narrative Generation Index*	2.23	(1.42)	[0–4]	3.19	(.86)	[1–4]	0.08

Asterisks (*) show when group-related differences were significant after Bonferroni correction for multiple comparisons.

Table 4

Cognitive profile of the two groups of participants with ASD. Data are expressed as means, standard deviations, and ranges. *Legend*: ASD: (children with) Autism Spectrum Disorders; TD: (children with) Typical development; ASD HighEFT: children with ASD who performed well on the EFT task; ASD LowEFT: children with ASD who did not perform well on the EFT task; ADOS-2: Autism Diagnostic Observation Schedule, 2nd Edition. Please, note that means, standard deviations and ranges of the group of children with typical development are available in Table 2.

	ASD LowEFT			ASD HighEFT			Effect size
	M	(SD)	[Min-Max]	M	(SD)	[Min-Max]	
Age	8.13	(1.51)	[6.00–11.09]	8.10	(1.52)	[6.00–11.07]	.00
Episodic Future Thinking Score*	2.90	(1.14)	[0–4]	6.65	(1.14)	[5–8]	.65
Ados 2 Gravity Index	6.53	(1.48)	[3–9]	5.85	(1.84)	[2–9]	0.04
IQ level	101.74	(12.95)	[82–130]	109.21	(14.09)	[80–141]	0.04
Digit Forward*	5.31	(1.20)	[3–8]	6.09	(1.44)	[3–10]	0.16
Digit Backward	2.90	(1.42)	[0–6]	3.94	(1.69)	[2–8]	0.06
Non-Word Repetition	32.00	(5.87)	[18–40]	33.55	(5.73)	[6–39]	0.01
Narrative Generation Index*§	3.97	(2.71)	[0–10]	8.38	(3.03)	[0–12]	0.33

	Frequency		Percent	Frequency		Percent	
Sex*							
Males	28		90.3	42		91.3	
Females	3		9.7	4		8.7	

Asterisks (*) show when group-related differences were significant after Bonferroni correction for multiple comparisons. § As for the Narrative Generation Index, among the group of ASD LowEFT 19 individuals scored 4 or lower (the minimum score obtained by the group of children with typical development); among the group of ASD HighEFT only 3 children scored 4 or lower (1 scored 0 and 2 scored 1).

explained 37% of the variance in the Narrative generation Index (t = 6.584, p < 0.001; R^2 = 0.366). For participants with TD, the predictor explained 82% of the variance in the Narrative generation Index (t = 2.588, p < 0.012; R^2 = 0.082).

3.3. Further analysis of episodic thinking skills in ASD

In order to further explore the possibility that a subgroup of children with ASD might experience significantly impaired future thinking skills, the group of participants with ASD was split in two subgroups according to their performance on the task of Episodic Future Thinking. As normative data for this task are currently not available, we considered a score of 5–8 at the *Picture Book Trip task* as normal as this was the range observed in the control group (see Table 4). As described in Ferretti et al. (2018a), this allowed us to identify a subgroup of participants with ASD who performed lower and one performing well on this task. This analysis revealed that 31 participants with ASD had significant difficulties in EFT, whereas 46 of them did not experience such difficulties. Interestingly, an inspection of the distribution of the scores obtained by the participants with ASD on this task showed the absence of a bimodal distribution suggesting the existence of a continuum in the ability showed by participants with ASD to process EFT. The two subgroups of individuals with ASD and the group of typically developing children had comparable chronological age ([F (2, 151) = 0.12, p = 0.887; η_p^2 = 0.002), level of formal education ([F (2, 151) = 0.094, p = 0.911; η_p^2 = 0.001), and IQ ([F (2, 151) = 0.094, p = 0.911; η_p^2 = 0.001) but different gender distribution [$X^2_{(1, N=154)}$ = 13.923, p < 0.001] (see Table 4). The Levene's test for equality of variances showed that on their performance at the EFT task the assumption of homogeneity of variance had not been violated (p = 0.531). Therefore, potential group-related differences between the three groups of participants (ASD children who performed lower on this task, those who performed well and the group of children with typical development) at the Trip Destination Task were assessed with a One-Way ANOVA. A significant group-effect was found on the EFT composite score ([F (2, 151) = 199.35, p < 0.001; η_p^2 = 0.649). Tukey's post-hoc analysis revealed that the participants with ASD who performed well on the task were no different than the control group (p = 0.195; d = 0.326), whereas the children with ASD who performed lower on the EFT task performed significantly worse than the ASD children who performed well (p < 0.001; d = 3.289) and the control participants (p < 0.001; d = 3.460). Importantly, the two subgroups of participants with ASD did not differ in the ADOS-2 Gravity Index either ([F (1, 74) = 2.93, p = 0.091; η_p^2 = 0.043) (see Table 4).

Before exploring the potential group-related differences on the target measures, preliminary analyses assessing homogeneity of variance were run. The Levene's test for equality of variances showed that on all of these measures the assumption of homogeneity of variance had not been violated with the only exception of performance at the Backward Digit Span Task (p < 0.013), performance at the Non-Word Repetition subtest of the PROMEA (p < 0.012) and the Narrative Generation Index (p < 0.045). For this reason, a non-parametric Kruskal-Wallis H test was run for these three scores. For this test, eta square was computed from the reported chi-square value test with the use of the following equation: $\eta^2 = (X^2/(N-1))$ where N is the total number of cases (Green & Salkind, 2008). For the remaining variables, a series of ANOVAs were run with group (ASD with good performance at the EFT task, ASD with lower performance at the EFT task, and children with TD) as fixed factor, and measures of IQ Level, and performance at the Forward Digit Span subtest of the WISC as dependent variables. The level of statistical significance was set at p < 0.001 (.05/5 dependent variables) after Bonferroni correction for multiple comparisons (see Table 4). When the group-effect was significant, post-hoc Tukey's test was performed. The results showed that the three groups had similar IQ Level ([F (2, 151) = 3.06, p = 0.050, η_p^2 = 0 .039),

Table 5

Episodic future thinking in the two groups of participants with ASD. Data are expressed as means, standard deviations, and ranges. *Legend*: ASD: (children with) Autism Spectrum Disorders; TD: (children with) Typical development; ASD HighEFT: children with ASD who performed well on the EFT task; ASD LowEFT: children with ASD who did not performed well on the EFT task. Please, note that means, standard deviations and ranges of the group of children with typical development are available in Table 3. Effect sizes are reported for the overall analysis of the performance of the three groups of participants. Asterisks (*) show when group-related differences were significant after Bonferroni correction for multiple comparisons.

	ASD LowEFT			ASD HighEFT			Effect size
	M	(SD)	[Min-Max]	M	(SD)	[Min-Max]	
Future Narrative Generation Index*	1.52	(1.09)	[0–4]	2.93	(1.29)	[0–4]	0.33
Middle Narrative Generation Index *	1.21	(1.07)	[0–3]	2.59	(1.09)	[0–4]	0.23
Past Narrative Generation Index *	1.33	(1.35)	[0–4]	2.81	(1.15)	[0–4]	0.24

performance at the Non-Word Repetition task ([X^2 (2) = 1.83; p = 0.401; η^2 = 0.013) and at the Backward Digit Span task (X^2 (2) = 9.20; p = 0.010; η^2 = 0.061). However, a significant group-related effect was found for the Forward Digit Span score ([F (2, 149) = 14.59, p < 0.001, η_p^2 = 0.164). The post-hoc analysis revealed that the two groups of participants with ASD performed similarly (p = 0.073; d = 0.588) and both scored lower than children with TD (p < 0.001; d = 1.188 and p < 0.006; d = 0.576 for the participants with ASD who performed worse or better on that task, respectively). Significant group-related effects were found also for the Narrative Generation Index (X^2 (2) = 51.69; p < 0.001; η^2 = 0.334) with a mean rank score of 27.82 for children with ASD who performed lower on the Episodic Future Thinking task, 81.30 for those who performed well on that task and 95.23 for the group of participants with TD. The pairwise comparisons showed that the participants with ASD who performed lower on the Episodic Future Thinking task scored lower than both children with ASD who performed better on this task (p < 0.001; d = 1.534) and TD (p < 0.001; d = 2.305). These last two groups did not differ from each other (p = 0.275; d = 0.424).

Finally, we explored whether significant differences could be found between the two groups of participants with ASD and the control participants also in the three sub-indices of narrative generation. The control for the performance on the task of nonverbal EFT was not done as this task had been used to create the two subgroups of participants with ASD. A series of preliminary analyses assessing homogeneity of variance revealed that the assumption of homogeneity of variance had been violated for the Future-Narrative Generation Index (p < 0.001) and the Past-Narrative Generation Index (p < 0.007) but not for the Middle-Narrative Generation Index (p = 0.940). Consequently, group-related differences on the former two variables were assessed with two non-parametric Kruskal-Wallis H tests whereas for Middle-Narrative Generation Index an ANOVA was run. The level of statistical significance was set at p < 0.017 (.05/3 dependent variables) after Bonferroni correction for multiple comparisons (see Table 5). Significant group-related differences were found in all of these measures: Future Narrative Generation Index (F NGI): (X^2 (2) = 51.36; p < 0.001; η^2 = 0.334); Middle Narrative Generation Index (M NGI): ([F (2, 148) = 22.19, p < 0.001, η_p^2 = 0.231); Past Narrative Generation Index (P NGI): (X^2 (2) = 37.01; p < 0.001; η^2 = 0.242). As for F NGI, children with ASD who performed lower on the Episodic Future Thinking task had a mean rank score of 31.02, whereas those who scored better on this task had a mean rank score of 79.28 and children with TD of 95.15. The pairwise comparisons showed that the participants with ASD who performed low on the Episodic Future Thinking task scored lower than both those with ASD who performed better on the same task (p < 0.001; d = 1.181) and children with TD (p < 0.001; d = 2.177) whereas those children with ASD who performed well on the Episodic Future Thinking task were no different from children with TD (p = 0.130; d = 0.544). As for M NGI, Tukey's post-hoc tests showed that children with ASD who performed lower on the Episodic Future Thinking task scored lower than both those with ASD who performed well on the same task (p < 0.001; d = 1.278) and children with TD (p < 0.001; d = 1.460). Finally, these two last groups of children did not differ from each other (p = 0.607; d = 0.175). As for P NGI, children with ASD who performed lower on the Episodic Future Thinking task had a mean rank score of 36.85, whereas those who scored well on this task had a mean rank score of 80.30 and children with TD had a mean rank score of 92.19. Also in this case, the pairwise comparisons confirmed that the participants with ASD who performed lower on the Episodic Future Thinking task scored lower than those with ASD who performed well on the same task (p < 0.001; d = 1.180) and children with TD (p < 0.001; d = 1.643). Finally, these two last groups of children did not differ from each other (p = 0.412; d = 0.374).

4. Discussion

This study examined EFT skills and narrative generation abilities (as well as their potential relations) in a large cohort of school-aged children with diagnosis of high-functioning ASD with minimal to high levels of autism spectrum related disorders. To the best of our knowledge, this is among the first studies assessing these functions in such a large cohort of children with ASD. The inclusion of participants with different severity levels of autistic symptomatology allowed us to rule out the possibility of a severity-bias that might affect their ability to complete the tasks. Their performance was compared to that of a group of children with typical development with comparable age, level of formal education, and IQ. Overall, the results confirmed that the *Picture Book Trip* task by Atance and Meltzoff (2005) can be used for the identification of ASD children with low EFT skills. Even more interestingly, the

analyses revealed that the EFT composite score predicted the narrative generation index in both children with ASD and with typical development. This lends further support to the hypothesis of an association between EFT skills and narrative generation that is not limited to micro- or macrostructural skills (as shown in Ferretti et al., 2018a) but extend also to the ability to generate an adequate scenario for the ongoing story. Finally, we observed that ASD children with low EFT skills had lower narrative generation abilities than those with ASD with normal EFT skills and children with typical development. These findings have theoretical, clinical, and methodological implications.

We begin by discussing the theoretical and clinical implications. Consistently with the few studies that have explicitly assessed EFT in children with ASD, our findings confirm the possibility of an impairment in EFT introducing also new elements in the current debate. They suggest that not all individuals with ASD manifest such difficulties and that those with impaired EFT might have also narrative generation impairments that are not limited to micro- and macrostructural aspects of narrative processing. This is an important new finding as it suggests that the narrative difficulties often reported in these children might be related to a difficulty in the temporal organization of the events in a narrative axis that affects the ability to generate the prelinguistic scenario of the story to be narrated. Indeed, those children who scored normally on the *Picture Book Trip task* performed well also on the narrative generation tasks. This opens new perspectives on the potential links between EFT and narrative production skills that need to be explored in future investigations. Furthermore, the identification of potential subgroups of children with ASD has important clinical implications. If confirmed also in future studies, the possibility that EFT is not homogeneously affected in individuals with ASD might contribute to explain the apparently discrepant results by Crane et al. (2013) who failed to find any group-related difference between 18 adults with ASD and 18 neurotypical adult participants on a sentence completion task employed to generate past and future event descriptions. According to the authors, this finding might have been biased by the particular methodology used in their study. However, as hypothesized in the Introduction, their negative result might also be related to the inclusion of a heterogeneous group of ASD participants including individuals with both impaired and unaffected EFT skills. Indeed, the potential existence of a subgroup of individuals with ASD who have impaired EFT and difficulties in other domains such as narrative production, opens the way to new possible rehabilitative approaches focusing on the improvement of such skills together with traditional training procedures. Furthermore, this study confirms that the *Picture Book Trip task* provides a good way to assess such skills in children with ASD. A further remark concerns the fact that both children with TD and children with ASD and normal EFT skills appear to be pretty much at ceiling on the *Picture Book Trip* task by Atance and Meltzoff (2005). As to this regard, recent evidence suggests its utility for monitoring the development of EFT skills in middle childhood (Ferretti et al., 2018b). In that study the task had been administered to a cohort of 135 Italian-speaking children with typical development aged between 6 and 11.06 years. Interestingly, children aged 6- and 7-year-olds correctly chose fewer items than older children and often failed to motivate their choice with respect to children from 8 years onward. Consequently, their EFT Score was lower than that achieved by older children. Participants aged 8–11 years scored similarly on these measures with some of them reaching ceiling level. As also in the cohort of participants of the current study with ASD children at least some participants over 8 years of age with typical development and with ASD with normal EFT skills reached ceiling level, this further confirms the similarity of the performance among these two groups and the need to disentangle the differences occurring in children with ASD and lower EFT skills.

Coming back to the theoretical implications of these findings, even when phonological short-term memory difficulties were accounted for in the analyses, the performance of the participants with ASD was still lower than that observed in the controls. This suggests that the difficulty observed in our sample of children with ASD in generating narratives and in foreseeing potential future scenarios might be only marginally affected by this cognitive function. Our findings support the possibility that EFT plays an important role in this process. However, the regression analyses showed that such involvement is quite limited, as scores on the task assessing EFT explained only 37% of the variance observed in the Narrative Generation Index in children with ASD but much more (89%) in children with TD. This means that in typical development the role played by EFT in narrative generation is quite significant. As children with ASD had more difficulties in such ability their narrative generation skills likely relied also on other abilities that need to be assessed in future studies. Indeed, a potential effect of executive functions, such as set shifting, inhibition and monitoring, cannot be ruled out. This is a limitation of our study that highlights the need of future investigations designed to explicitly assess such relations in large cohorts of children with ASD.

A third important finding of the current study concerns the possibility that EFT directly contributes to narrative generation ability. We are aware of only two previous investigations assessing the relation between EFT and narrative production skills (Ferretti et al., 2018a; Lind, Bowler, et al., 2014). Of these, Lind, Williams, et al. (2014) used a narrative production task to control for the ability of a group of 27 adults with high-functioning ASD to generate a coherent narrative discourse. The participants were asked to tell the story depicted on a 24-pages picture-book. The narrative samples were transcribed and analyzed in order to derive a measure of productivity (i.e., story length in words), one of narrative construction (i.e., global structure score), and one of semantic content (semantic score). A multivariate analysis of variance failed to show any group-related differences on the combined dependent variables and the authors claimed that difficulties in the ability to provide descriptions of past events, potential future scenarios, and imagined fictitious episodes are unlikely related to basic difficulties in narration (p. 62). This is apparently at odds with the findings of our study. However, there are reasons to suggest that this is not necessarily the case. First of all, the picture story description task used in Lind, Bowler, et al. (2014) and Lind, Williams, et al. (2014)'s study relies on the ability to verbally generate a story whose conceptual structure was explicitly available to the subject (it was portrayed in the images that (s)he was asked to describe). In our study, children were instructed to generate coherent episodes at the beginning, in the middle, or at the end of a story. Importantly, these episodes were not explicitly provided by the experimenters by any means. Rather, children were required to generate them by recruiting pertinent pieces of information in their episodic and semantic memory and integrating these potential scenarios with the contents portrayed in the available pictures. This is an important difference as the participants were required to self-generate the

requested episodes without a visual support that had visually provided the gist of the story. Second, the two studies had very different participants: adults in Lind et al.'s and children in ours. This leaves open the possibility of a developmental difficulty in the ability to generate coherent narratives in ASD that might become less evident with adulthood. Overall, then, our investigation supports the hypothesis of a relation between impaired EFT and difficulties in the generation of coherent narratives. Such hypothesis is further corroborated by another finding that is noteworthy. Interestingly, the subgroup of children with ASD who performed well on the EFT task had a narrative performance that was similar to that of control participants. Overall, these data suggest the possibility of a connection between EFT skills and narrative generation abilities which is supported also by the significant correlation found in all groups between the narrative generation indices and the episodic future thinking score. This connection should be further analyzed in future studies.

The same consideration holds true also from a methodological point of view. Our results highlight the need for more studies addressing the characteristics of EFT in large cohorts of children with ASD. Particular attention should be paid to the selection of both participants with ASD (including children with different levels of severity of autistic symptomatology in order to avoid a severity bias) and children with TD (that in case of children with high functioning ASD should be possibly matched for age and IQ as a minimum). This would allow scholars and clinicians to limit the problem of the high heterogeneity observed in children with ASD. Furthermore, this study also suggests that tasks requiring narrative skills to assess EFT should be replaced or at least supported by narrative-free tasks. Our experience shows that the *Picture Book Trip task* by Atance and Meltzoff (2005) is useful not only with preschoolers but also with school-aged children with ASD. Nonetheless, the development of new tests of this kind is strongly advised. A final note regards two potential limitations of the current study. The former concerns the absence of a screening for ASD in the control group. Even if all participants were assessed for basic cognitive skills and an interview with their teachers allowed us to exclude potentially problematic children, the lack of quantitative measures expressively addressing this possibility did not allow us to rule out the possibility that some of these individuals might have had autistic traits. In our opinion, such a screening should be included in future investigations. The second limitation concerns the scoring procedure. Although informative about the children's narrative generation skills, we acknowledge that the 3-point scoring system (0: no events generated; 1: a minimal level of narrative generation; 2: the introduction of two or more new story elements) for the narrative generation task might have not been sensitive enough as to discriminate between children with different levels of narrative generation skills. In our opinion, future studies should apply more accurate procedures of narrative assessment (e.g., Guarini et al., 2016; Marini, Andreetta, Del Tin, & Carlomagno, 2011; Marini & Urgesi, 2012) that include reliable measures of productivity (in terms of speech rates and mean length of utterances), lexical and grammatical skills as well as the ability to generate coherent and informative samples of narrative discourse.

5. Conclusions

In conclusion, our results 1) support the hypothesis that EFT may be impaired in some but not all children with ASD, 2) support the hypothesis of a relation between such difficulties and impairments in the generation of narratives, and 3) confirm that the assessment of EFT should employ tasks that do not require narrative production, as children with reduced EFT may have also limited narrative skills. Future studies are needed to further extend our comprehension of the complex relation between episodic future thinking, narrative generation and executive functions.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jneuroling.2018.07.003.

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