Language Sciences 93 (2022) 101500

Contents lists available at ScienceDirect

Language Sciences

journal homepage: www.elsevier.com/locate/langsci

How do we comprehend linguistic and visual narratives? A study in children with typical development

Ines Adornetti [a,*], Alessandra Chiera [a], Daniela Altavilla [a], Valentina Deriu [a], Camilla Maria Lecci [a], Andrea Marini [b,c], Giovanni Valeri [d], Rita Magni [e], Francesco Ferretti [a]

[a] *Cosmic Lab, Department of Philosophy, Communication and Performing Arts, Roma Tre University, Via Ostiense 234-236, 00146, Rome, Italy*

[b] *Department of Languages and Literatures, Communication, Education and Society, University of Udine, Via Margreth, 3, I-33100 Udine, Italy*

[c] *Claudiana - Landesfachhochschule für Gesundheitsberufe, Bozen, Italy*

[d] *Child and Adolescent Neuropsychiatry Unit, Department of Neuroscience, The Bambino Gesù Children's Hospital, IRCCS, Piazza di Sant'Onofrio 4, 00165 Rome, Italy*

[e] *Studio Polispecialistico Evò, Viale Pier Luigi Nervi 164, 04100 Latina, Italy*

ARTICLE INFO

Article history:
Received 27 January 2022
Received in revised form 16 June 2022
Accepted 5 July 2022
Available online xxx

Keywords:
Central coherence
Linguistic narrative
Narrative global coherence
Narrative comprehension
Theory of mind
Visual narrative

ABSTRACT

The present study investigated the comprehension of narrative with reference to global coherence, i.e., the global representation of story meaning and connectedness, across two different expressive modalities: stories conveyed through written language and stories conveyed through sequences of images. Two cognitive abilities possibly underpinning such comprehension were assessed: Central Coherence (CC) and Theory of Mind (ToM). Two groups of children with typical development aged between 8.00 and 10.11 years were included in the study: 40 participants received the narrative comprehension task in the linguistic modality; 40 participants were administered the narrative comprehension task in the visual condition. Analyses revealed that a change in the expressive code used to convey narratives did not entail a change in the overall comprehension performance: children of the two groups performed similarly on the narrative task. As for the cognitive abilities, CC and ToM scores were positively correlated with narrative comprehension score only in the visual narrative comprehension task, and not in the linguistic one. Moreover, a regression analysis showed that, along with age, CC significantly predicted the visual narrative comprehension score. The implications of these results are discussed.

1. Introduction

The ability to process narratives, i.e., temporally and causally connected sequences of events driven by the goals and motivations of one or more agents which unfold toward an outcome, is thought to be uniquely human (Boyd, 2018; Corballis, 2017; Ferretti, 2021, 2022; Ferretti et al., 2017; Ferretti and Adornetti, 2021; Scalise Sugiyama, 2005; Smith et al., 2017). Telling and comprehending stories is fundamental to the human condition (Bruner, 2010) and crucial for mind development and social

* Corresponding author. Cosmic Lab, Department of Philosophy, Communication and Performing Arts, Roma Tre University, Via Ostiense 234, 00146, Rome, Italy.

E-mail address: ines.adornetti@uniroma3.it (I. Adornetti).

https://doi.org/10.1016/j.langsci.2022.101500
0388-0001/

interaction (Gottschall, 2012; Smith et al., 2017). Given the central role of stories in human life, in the last decades many investigations have explored the nature of narrative processing: its cognitive underpinnings (e.g., Boerma et al., 2016; Chrysochoou et al., 2011; Dore et al., 2018), neural substrates (e.g., Cohn-Sheehy et al., 2021; Ferstl et al., 2008; Lin et al., 2018; Mar, 2004; Mason and Just, 2009; Yuan et al., 2018), ontogenetic development (e.g., Goldman and Varnhagen, 1986; Hacker, 1997; Helder et al., 2016; Karmiloff-Smith, 1985; Lynch et al., 2008; Szaflarski et al., 2012; Trabasso and Nickels, 1992; Paris and Paris, 2003), and its impairment in neurodevelopmental disorders (e.g., Autism Spectrum Disorders, ASD: Coderre et al., 2018; Ferretti et al., 2018; Jolliffe and Baron-Cohen, 2000; Marini et al., 2019; Nuske and Bavin, 2011). In general, these investigations suggest that narrative is a complex process that relies on a variety of linguistic (lexical, syntactic, and pragmatic) skills (e.g., Norbury et al., 2014; Westerveld and Gillon, 2010) as well as cognitive abilities necessary to remember and sequentially organize a set of events (Kelter et al., 2004), create and maintain perspectives of several characters (Fletcher et al., 1995; Mason and Just, 2009), and use information from both within and outside the text to construct a mental model of the narrative text (Kintsch, 1988; Zwaan and Radvansky, 1998). As for the development of story processing, studies showed that low-level narrative comprehension (e.g., Trabasso and Nickels, 1992) and production (McCabe and Peterson, 1991; Peterson and McCabe, 1983) abilities emerge around the age of 4 and 5 years and become quantitatively and qualitatively different in middle childhood (Goldman and Varnhagen, 1986).

Within this framework of studies, a productive line of research is that aimed at exploring the similarities and differences between the processing of story meaning in different modalities (e.g., textual, visual, auditory; Coderre et al., 2018; Kress, 1997; Manfredi et al., 2020). Indeed, studies emerged in the context of narrative theory have shown that stories are not restricted to the verbal modality but can be conveyed non-linguistically through several expressive systems (Sibierska, 2017). An interesting issue in this regard is understanding the effects of specific expressive systems on narrative comprehension, i.e., if a change in the expressive medium is also tied to a change in the comprehension processes (e.g., Altun, 2021; Walsh, 2003; Wannagat et al., 2021). The present investigation addresses the issue of the expressive modalities of narrative through the lens of children's development. From an early age, children are exposed to stories conveyed in various forms: from stories told aurally to picture books, narratives are claimed to represent a fundamental tool for children's learning processes (e.g., Lynch et al., 2008; Nyhout and O'Neill, 2014; Williams and Horst 2014), promoting and interacting with the development of their language, literacy, and socio-cognitive abilities (Veneziano and Nicolopoulou, 2019). For example, it has been shown that narrative comprehension is an important precursor to reading achievement (e.g., Paris and Paris, 2003; Roth et al., 1996) and that exposure to stories improves mentalizing abilities (Mar, 2018). Given the importance of narrative in human cognitive development, understanding if narratives presented in different modalities also rely on specific comprehension processes may provide useful indications on how and under which circumstances stories can be more effective for the development of various children's skills, thus orienting pedagogical and clinical interventions.

In the context of developmental research, Wannagat and colleagues (2021) compared comprehension of monomodal (auditory) and multimodal (both auditory and visual [i.e., administered also via pictures]) narratives in children aged between 9 and 12 years. Their results showed that the two types of narratives were processed differently in terms of response times: in texts presented in both modalities children were faster at responding to a query word, which could be associated with a near or a distant antecedent of the final utterance, compared to texts presented only in the auditive modality. According to the authors, "pictures seem to facilitate memory resonance with both near and distant antecedents" (Wannagat et al., 2021, p. 301), thus making it easier to connect the events of a story (see also Pike et al., 2010). These considerations are consistent with the assumption that pictures are a universal and primary aspect of human expression (Petersen, 2011) that is more easily processed than linguistic stimuli. Visual stimuli are claimed to directly reflect concrete spatial aspects of the real world (Quill, 1995) that would make them fairly transparent, allowing for an easy mapping into event knowledge. According to this view, transparency – leading to universality – implies that sequential images are "understandable by everyone – including young children – with little learning or decoding (e.g., McCloud, 1993). This assumed transparency likely arises from beliefs that they require basic perceptual or event cognition alone" (Cohn and Magliano, 2020, p. 201). Such a view has been critically defined the *myth of transparency* (Cohn and Magliano, 2020) or *the visual ease assumption* (Coderre, 2020).

Over the past few years, neurocognitive studies have challenged the view that sequential images processing requires only basic perceptual cognition. Investigations have addressed the issue by assessing whether the abilities used to process narratives are specialized for single modalities (e.g., Coderre et al., 2020; Cohn 2020; Manfredi et al., 2017; West and Holcomb, 2002; Yuan et al., 2018). The focus has been mainly on the comparison between linguistic and visual narratives (e.g., Magliano et al., 2019; Magliano et al., 2013). The latter have been defined as sequences of images created with the intention of conveying meaning, generally through the representation of one or more events in succession (Cohn, 2019; Cohn and Magliano, 2020), with the meaning being transmitted both locally (in correspondence of the single images) and globally (among the sequences of images). Neurophysiological studies focusing on Event-Related brain Potentials (ERPs) have revealed a cortical overlap between the processing of meaning in written and visual stories. For example, the N400 is elicited not only by the congruency of a sentence-final word with its preceding context during comprehension (Kutas and Federmeier, 2011; Kutas and Hillyard, 1980), but also by a final image that is semantically anomalous in the visual narrative context (e.g., Cohn et al., 2012; Jouen et al., 2021; West and Holcomb, 2002).

A similar effect evoked by stimuli across modalities has been observed with the P600, an ERP that reflects the cost of integrating the meaning of incoming information into the global representation of a discourse (e.g., Brouwer et al., 2017; Delogu et al., 2019): also in visual narratives, the P600 appears to be modulated by incongruous information or critical framing changes that require to be mapped to the whole content via costly updating or revision processes (e.g., Cohn and Foulsham, 2020; Cohn and Kutas, 2015).

The present behavioral study aims at exploring the comprehension of stories conveyed through written language and visual pictures in children with typical development. The focus on the ontogenetic development offers insight into the possible role of different modalities on the processing of story meaning. This might have important pedagogical and clinical implications.

1.1. Linguistic and visual narrative comprehension: processes and development

Narrative processing includes both production and comprehension abilities. Although strongly interrelated, they can be analyzed separately as consisting of partially different processes (AbdulSabur et al., 2014). The present study focuses on narrative comprehension, which “refers to the access of semantic information – how various themes, characters, and plotlines fit together – mediated by narrative structures” (Coderre et al., 2018, p. 45). In particular, the current investigation compares written and visual narrative comprehension in reference to the story plot and, more specifically, to the main property governing the temporal and causal structure of the story plot, namely global coherence. Narrative global coherence concerns the way a narrative is organized with respect to an overall goal, plan, theme, or topic (Glosser and Deser, 1991) and can be generally defined as the global representation of story meaning and connectedness. Such representation integrates knowledge about how events, actions, objects, and situations are interrelated and organized through causal and temporal relations (De Beaugrande, 1980; Trabasso et al., 1995). As the ability to construct a coherent mental representation of a story is crucial for the comprehension of both written and visual narratives (Bateman and Wildfeuer, 2014; Graesser et al., 1994; Kintsch, 1998; McNamara and Magliano, 2009), the current investigation aims at analyzing the cognitive underpinnings of the comprehension of global coherence across these two different expressive modalities (i.e., visual and linguistic). It also assesses whether a change in the expressive medium is related to differences in its comprehension.

According to one prominent theoretical model of text comprehension, readers are required to construct different levels of representation to build a coherent mental model of the story plot (van Dijk and Kintsch, 1983). These levels include: the representation of the text information in its verbatim form; the representation of a network of coherently linked propositions; the representation of the situation model of the event described in a text which, in turn, incorporates the representation of features such as time, space, causal relations, and characters (Zwaan and Radvansky, 1998), and integrates (through inferential processes) the reader’s prior knowledge with the information explicitly stated in the text. Developmental research revealed that the ability to construct a coherent mental representation of a written text develops greatly during childhood and adolescence (e.g., Hacker, 1997; Helder et al., 2016; Lynch and van den Broek, 2007). In this regard, to explore the children’s ability to monitor the global coherence of a story, most studies employed error-detection paradigms and highlighted that older children can detect coherence disruptions better than younger ones (Garner, 1981; Hacker, 1997; Helder et al., 2016; Vosniadou et al., 1988).

As for the cognitive processes underpinning text comprehension, a study by Jolliffe and Baron-Cohen (2000) suggested that a crucial ability involved in the construction of a coherent mental representation of the story plot is Central Coherence (CC). CC is a cognitive ability assumed to be responsible for integrating the single elements of an event into a wider global context at both the conceptual (i.e., semantic) and perceptual (i.e., visual) level (Frith, 1989; Happé et al., 2001; López et al., 2008; Plaisted, 2001). In a study by Jolliffe and Baron-Cohen (2000), adults with ASD were administered The Global Integration Test, which requires participants to rearrange sentences describing the single events of a narrative in accordance with a theme to tell the most coherent story. Participants with ASD, who tend to process information locally focusing on details without being able to integrate them into a wider global context (Frith, 1989; Happé et al., 2001), were less able to integrate sentences with each other to construct a coherent narrative. This supports the view that CC allows for the integration of single pieces of information at a global story level (see also Nuske and Bavin, 2011).

A crucial role in a narrative text is also played by characters’ actions, motivations, and emotions (e.g., Bower and Rinck, 1999; Chiera et al., 2022; Lynch and van den Broek, 2007). Therefore, the construction of a coherent mental representation of a text requires an understanding of psychological/motivational causes of characters’ actions (Wannagat et al., 2021). The major cognitive ability recruited for such a process is Theory of Mind (ToM). ToM is a broad term referring to the cognitive ability allowing us to explain others’ behavior in terms of their thoughts, feelings, emotions, beliefs, and desires (e.g., Baron-Cohen, 1995; Frith and Frith, 2005; Wellman et al., 2001). There is growing evidence that the human mind treats fictional characters as real persons: ToM, which is used to understand people’s goals and motivations in daily social interactions, is also recruited to give meaning to the actions described in narratives (Gerrig, 2010; Ferretti and Adornetti, 2020; Oatley, 1999).

As for visual narrative comprehension, research on the topic is an emerging field of investigation (Cohn and Magliano, 2020). While visual narratives are used in several studies (e.g., Marini et al., 2008; Marini et al., 2011; Zalla et al., 2006), in most cases such a use is not aimed at directly evaluating the processes responsible for comprehension of the visual-pictorial aspects of stories but is secondary to testing other skills. Research on storytelling abilities in persons with ASD provides a good example in this regard. Most experiments that explored narrative production in children with ASD (e.g., Diehl et al., 2006; Norbury and Bishop, 2002; Young et al., 2005; for a review, see Stirling et al., 2014) employed picture books, such as *Frog, where are you?* (Mayer, 1969), as materials aimed at eliciting storytelling. The choice of materials of this kind is implicitly linked to the above-mentioned myth of transparency. Under the assumption that the comprehension of a story portrayed in sequential images only requires basic perceptive skills and the simple ability of event comprehension, these studies do not seem to consider the possibility that the well-attested storytelling difficulties of people with ASD might stem from an impairment in decoding the visual-pictorial aspects of story and not (or not exclusively) from weakening in narrative linguistic production (Adornetti et al., 2020; Coderre et al., 2018).

Indeed, as already noted, visual narrative research shows that the abilities involved in the processing of visual narratives are anything but basic – much more is needed than simple perceptual skills (for a review, Cohn, 2020a; 2020b).

Developmental research further contributes to highlight the complexity of visual narrative processing. It indicates that comprehension of visual narrative sequences follows a clear developmental trajectory (Cohn, 2020b), which starts around the age of 4. Before this age, children typically narrate the content of each picture of a visual story as if it represents an isolated event, i.e., without integrating it in the sequence of events (e.g., Trabasso and Stein, 1994). The abilities required to fully comprehend visual narratives, identifying continuity, and thus making connections across sequential images, emerge around the age of 4 (Trabasso and Nickels, 1992; Trabasso and Stein, 1994) and reach full competence between 5 and 6 (Bornens, 1990). In this age range, children begin to be proficient at picture arrangement tasks, where they are required to order into coherent sequences images of stories presented in a random order (e.g., Friedman, 1990). This age range is also when children can infer implicit content that is not depicted in a sequence (Zampini et al., 2017) and this ability increases through age 14 (Nakazawa and Nakazawa, 1993). Importantly, it has been observed that this ability is also affected by exposure and experience with visual narratives (Cohn, 2020b). The trajectory observed in the development of visual narrative processing is particularly interesting also because it goes along with the development of diverse aspects of cognition that underlie both linguistic and visual narrative abilities in a similar fashion (West and Holcomb, 2002; Cohn et al., 2012; Magliano et al., 2016). Indeed, the comprehension of sequential images relies on processes of semantic integration of information between the various images and the construction of a global representation of the unfolding events, namely a situation model of the scene (Cohn, 2019). Moreover, like in linguistic narrative, such semantic processing is complemented by the construction of a narrative grammar, which organizes this information in terms of the structural elements of a story (e.g., an initiating problem, attempts to resolve that problem, and an outcome) (Cohn et al., 2014). Additionally, visual narrative comprehension relies on the understanding of psychological/motivational causes of characters' actions and, thus, on the involvement of ToM (e.g., Baron-Cohen et al., 1986). This is in line with some findings indicating the existence of a mentalistic cross-modal "narrative hub" that transcends the modalities of expression (e.g., Yuan et al., 2018). Lastly, the different representational format also requires specific processes not involved in the comprehension of linguistic stories (Cohn and Magliano, 2020). For example, bridging inferences, which allow to establish how two or more events are connected, "in visual narratives involve attentional selection and visual search of images – aspects of scene perception that cannot occur in text" (Cohn and Magliano, 2020, p. 203).

Overall, from the considerations made so far two different accounts emerge regarding the processing of visual and linguistic narratives. On one side, there are investigations indicating that the process of connecting the story's events is easier when narratives are presented in pictures (Wannagat et al., 2021; Pike et al., 2010), thus supporting the visual ease assumption. On the other, there are studies indicating that visual narrative processing is not straightforward: as shown by developmental findings reported above, when single pictures are inserted into a temporal and causal connected sequence of images comprising a story line, cognitive demands become higher. On this vein, research has shown that the ability to order sequential images are modulated by the experience that children have, for example, with comics (Nakazawa, 2016). The not conclusive indications coming from developmental and neurocognitive research open the way to the need of more careful examination of the modality-specific aspects of narrative development. A promising approach in this regard is making a direct comparison between different modalities to explore how and to what degree the narrative modality manipulation affects the processing of stories.

1.2. The present study

The main aim of this study is analyzing the process of establishing narrative coherence by comparing the comprehension of written and visual narratives in children with typical development. Specifically, two research questions underlie the present investigation: 1) to assess whether the comprehension of narrative global coherence is affected by the expressive medium used to convey a story; 2) to explore the role of two specific cognitive abilities recruited for understanding global coherence in the linguistic and visual modalities: CC and ToM. As mentioned above, there are studies suggesting that CC is involved in the construction of a coherent mental representation of the story plot in linguistic narratives (Jolliffe and Baron-Cohen, 2000; Nuske and Bavin, 2011). The present study aims to explore if a similar role can be also detected for narratives conveyed through sequences of pictures. As CC is responsible for integrating the single elements of an event into a wider global context at both the semantic and visual level, we expect to find an involvement of CC in both written and visual narrative comprehension. Similarly, as the construction of a coherent mental representation of a story involves an understanding of psychological causes of characters' actions, we expect that ToM would be equally recruited in the two narrative tasks.

2. Materials and methods

2.1. Participants

Eighty Italian-speaking children with typical development aged between 8 and 10.11 years were included in this study. They formed two groups matched on gender, chronological age, level of formal education, and IQ level, which was in the normal range as assessed through the Raven's Coloured Progressive Matrices (Raven, 1938; Italian standardization: Belacchi et al., 2008) (see Table 1). The first group included forty children who received the narrative comprehension task in the linguistic (written) modality (*Linguistic Narratives Group*: LNG). The second group consisted of forty children who were administered the narrative comprehension task in the visual condition (*Visual Narratives Group*: VNG).

Children were recruited in local schools. All participants had normal or corrected-to-normal vision. In a preliminary interview, their teachers confirmed that they had normal cognitive development, as well as average school performance. According to parents' reports, none of them had a known history of psychiatric or neurological disorders, learning disabilities, hearing or visual loss.

This study was approved by the ethical committees of Roma Tre University and "Bambino Gesù" Children Hospital in Rome. Parents signed the consent form for the participation of their children to the study and for the treatment of the data.

Table 1
General data of the two groups of participants.

	Linguistic Narratives Group ($n = 40$) M (SD) [range]	Visual Narratives Group ($n = 40$) M (SD) [range]
Age	9.20 (0.84) [8–10.11]	9.07 (0.76) [8–10.11]
Education	3rd - 5th grade	3rd - 5th grade
Gender distribution	Males = 18 (45%) Females = 22 (55%)	Males = 19 (47.5%) Females = 21 (52.5%)
IQ level	106.25 (12.54) [90–130]	104.25 (11.07) [80–130]

Data are expressed as means (M), standard deviations (SD), and ranges.

2.2. Procedures

The children were tested individually at school. Both groups received two testing sessions to minimize fatigue. On the first day, the children were administered the Raven's Progressive Matrices (Raven, 1938; Italian standardization: Belacchi et al., 2008) and a test aimed at assessing their attention skills (the *Modified Little Bells test*; Biancardi and Stoppa, 1997). The latter was included in the study to control for the presence of potential attention difficulties. On the second day, children were administered two subtests from the NEPSY-II (Korkman et al., 2007; Italian standardization: Urgesi et al., 2011), a standardized battery for neuropsychological assessment of children aged 3–16 years, aimed at assessing two cognitive abilities: ToM (through the *Theory of Mind-part B*) and CC (through the *Picture Puzzles*). Finally, the participants were randomly divided in two groups to assess narrative comprehension: one group received the narrative task in the linguistic (written) version; the other group received the same narrative task in the visual modality. The group of children who received the narrative task in the written modality was also administered a task aimed at assessing reading abilities (Cornoldi et al., 2017), which resulted in the normal range.

2.2.1. Assessment of attention skills

To evaluate children's selective and sustained attention the *Modified Little Bells test* (Biancardi and Stoppa, 1997) was used. Participants were shown four different sheets, each containing illustrations representing a series of little bells embedded among other items (e.g., cars, guitars, keys, trees, horses, etc.). For each sheet, the children had 2 min to mark with a pencil the little bells: during the first 30 s, participants used a red pencil; for the remaining 90 s, they used a blue pencil. The children did not know in advance how much time they had, nor how many sheets would have been presented to them or the number of bells on each sheet. This test allowed us to obtain two scores: a rapidity score, obtained by summing up the total number of bells the children could find in the first 30 s per sheet (i.e., the bells marked in red); an accuracy score, derived by summing up the total number of bells (i.e., marked both in blue and red) found on all four sheets after the 2 min.

2.2.2. Theory of mind task

The *Theory of Mind-part B* (Affect Recognition) subtest from the NEPSY-II (Korkman et al., 2007; Italian standardization: Urgesi et al., 2011) was employed to assess the children's ability to understand others' emotional states and feelings. They were presented with 9 pictures depicting a target individual, i.e., a girl named Julia engaged in different social contexts (e.g., riding a roller coaster; watching a broken window while wearing a baseball glove). The face of the target individual was not shown. Therefore, the children were asked to select from four options the photograph that depicted the appropriate emotion (or mental state) of the girl in the picture. The experimenter told participants "Show me the photo that shows how Julia feels". The first item was used as a trial. One point was assigned for each correct answer for a maximum of 8 points. The Cronbach's alpha was .24. This low value probably reflects the fact that in the present study only one of the two subtests of the tasks constituting the *Social Perception* domain[1] included in the NEPSY-II was administered.

2.2.3. Central coherence task

The children's ability to discriminate between constituent parts of a picture and to recognize visual part–whole relationships, i.e., CC, was assessed through the *Picture Puzzles* subtest from the NEPSY-II (Korkman et al., 2007; Italian standardization: Urgesi et al., 2011). The participants were presented with a large entire picture divided by a grid and four

[1] The *Social Perception* domain included in the NEPSY–II in the Italian standardization (Urgesi et al., 2011) consists of Theory of Mind part A and Theory of Mind part B. The Theory of Mind part A task is designed to assess the ability to decode and interpret others' intentions/points of view and understand how these influence behavior.

smaller pictures taken from sections of the larger picture. They had 45 s to identify the location on the grid from which each of the smaller pictures was taken. Children obtained 1 point for each item if they correctly selected the four parts within the given time (if performance exceeded the time, they received 0 points). A response time was calculated whether the children completed the item in the given time or not. The first item was used as a trial. The participants aged until 10 years old received 7 items for a maximum score of 7 points while the children aged over 10 years old were presented with 13 items, for a maximum score of 13 points (Cronbach's alpha .76). For the data treatment, scores were transformed in percentage and response times were normalized.

2.2.4. Narrative comprehension task

The narrative comprehension task aimed at assessing children's ability to understand a narrative's global coherence by arranging in the correct order the constituent parts of stories presented in sentences (for the children of the LNG) or pictures (for the children of the VNG). The stories were adapted from Quintarelli and Busani (2015), an activity book used to practice temporal and logical abilities through the comprehension of visual sequences of events, by selecting some images that were relevant for our task. The task was based upon a study carried out by Jolliffe and Baron-Cohen (2000), who had explored the ability of adults with autism or Asperger's syndrome to arrange sentences constituting stories. Differently from that study, our investigation analyzed the narrative comprehension of children with typical development, rather than adults with ASD, and focused on two narrative representational formats – visual and written – rather than one. Furthermore, to make the task suitable for the children, in the present study each narrative consisted of six sentences (for the LNG) and six pictures (for the VNG), whereas in Jolliffe and Baron-Cohen (2000) experiment each story comprised five sentences. It is important to stress that this variation is in line with Jolliffe and Baron-Cohen's theoretical background, according to which evaluating the global level of a story requires five or more sentences (or pictures) since this level generally includes "information that is not in short-term or working memory at one time" (p. 1170).

In the written narrative comprehension task, the children were shown six stories, the first of which was used as a trial. Each story consisted of six sentences corresponding to the constituent events of the narrative. The participants were told that they were going to read some sentences making up a story and they would eventually be asked to rearrange the sentences in the correct order. Therefore, to correctly rearrange the sentences, children needed to understand how the sequences of events unfolded toward an outcome: they had to establish connections between widely separated pieces of information, identifying the correct temporal and causal sequence linking the events. For each story, the sentences were presented in a random order that was the same for all participants. The sentence describing the beginning of each story was never placed in the first position. Similarly, the correct sentence relating to the end of each story was never placed in the last position. Once the experimenter read aloud the story's title and placed it down on the table at the head of the story sequence, the response time was calculated (narrative comprehension response time). The children received 1 point for each story that had been correctly ordered with respect to all its constituent parts (narrative comprehension score), for a maximum of 5 points (given that the first item was a trial).

For example, one story titled *Andrea's snack time* was the following: 1) Andrea goes to the kitchen because it's snack time; 2) The mum gives Andrea a banana; 3) Andrea goes out into the garden to eat the banana; 4) Andrea throws down the banana peel and mum notices; 5) Mum is angry and explains to Andrea to not throw down the waste; 6) Andrea throws the peel in the trash. The order of presentation was: 6-2-5-3-1-4. Another story, titled *Mum slips*, was the following: 1) Coming down the stairs, the mum slips on a little ball and tumbles down; 2) The dad helps mum to get up; 3) Dad bands the mum's ankle and applies a Band-Aid on the knee; 4) Martina starts crying when she sees the Band-Aid; 5) Mum hugs Martina to console her; 6) Dad and Martina give mum a box of chocolates with a greeting card. The order of presentation was 5-2-6-3-1-4.

The visual narrative comprehension task consisted of the same stories presented in the written task. Specifically, each of the six sentences constituting the six written stories was translated in an image depicting each constituent event of the story (the pictures did not contain any words). Therefore, the content of the narratives was the same for the two conditions. The procedure of administration of the visual narrative comprehension task was similar: stories were presented in the same order and, for each story, the order of presentation of the individual pictures was the same of the order of presentation of the individual sentences. Also in this case, a first item was used as a trial. The children were told that they were going to see some pictures making up a story and that they would eventually be asked to rearrange the images in the correct order. The experimenter read aloud the story's title and placed it down on the table at the head of the story sequence. Then, the response

Table 2
Performance of the two groups (Linguistic Narratives Group *vs* Visual Narratives Group) on the tasks assessing attention skills, central coherence, theory of mind, and narrative comprehension.

	Linguistic Narratives Group M (SD) [range]	Visual Narratives Group M (SD) [range]
Selective attention – rapidity score	46.05 (9.48) [27–63]	43.68 (9.43) [25–71]
Sustained attention – accuracy score	115.85 (14.22) [81–136]	110.25 (19.43) [58–150]
Theory of mind	6.27 (1.01) [5–8]	6.22 (1.31) [3–8]
Central coherence score	76.01 (27.24) [0–100]	71.39 (27.85) [0–100]
Central coherence response time	155.05 (42.82.05) [77–261]	172.05 (52.58) [105–370]
Narrative comprehension score	2.15 (0.98) [1–4]	2.35 (1.17) [1–5]
Narrative comprehension response time*	395.48 (139.03) [194–674]	252.37 (116.34) [111–713]

Data are expressed as means (M), standard deviations (SD), and ranges.
Asterisks* shows when group-related differences were significant.

time was calculated (narrative comprehension response time). The participants received 1 point for each story that had been correctly ordered with respect to all its constituent parts (narrative comprehension score), for a maximum of 5 points.

3. Results

The group-related differences (i.e., LNG *vs.* VNG) on the children's selective attention (rapidity score), sustained attention (accuracy score), ToM score, CC score, CC response time, narrative comprehension score, and narrative comprehension response time were analyzed using a series of *t*-tests on seven measures related to these skills. As shown in Table 2, a significant difference between the two groups was found on the narrative comprehension response time [($t_{(78)} = 4.99$); $p < .001$], with the children in the VNG characterized by lower response times than those in the LNG. No differences emerged between the two groups on selective attention [($t_{(78)} = 1.12$); $p = .265$], sustained attention [($t_{(78)} = 1.47$); $p = .145$], ToM [($t_{(78)} = .19$); $p = .849$], CC score [($t_{(78)} = .75$); $p = .455$], CC response time [($t_{(78)} = -1.59$); $p = .117$], and narrative comprehension score [($t_{(78)} = -.83$); $p = .408$].

The association between age, ToM, CC (score and response time), and narrative comprehension (score and response time) was investigated by using Pearson's correlation coefficient on the two groups of participants. In the LNG no correlations emerged between the narrative comprehension score and age ($r = .13$; $p = .403$), CC score ($r = -.01$; $p = .941$), CC response time ($r = -.14$; $p = .374$), and ToM ($r = .14$; $p = .393$); the narrative comprehension response time negatively correlated only with CC score ($r = -.34$; $p < .033$). In the VNG, the narrative comprehension score positively correlated with age ($r = .43$; $p < .006$), CC score ($r = .47$; $p < .002$) and ToM ($r = .38$; $p < .015$); the narrative comprehension response time positively correlated with CC response time ($r = .60$; $p < .001$); no correlations emerged between the narrative comprehension score and CC response time ($r = -.02$; $p = .899$) (see Table 3).

Table 3
Correlation analyses between Age, Central Coherence score, Central Coherence response time, Theory of Mind and narrative comprehension (score and response time) in the Linguistic Narratives Group (LNG) and Visual Narratives Group (VNG).

		Age	Central Coherence score	Central Coherence response time	Theory of Mind
Narrative comprehension score	**LNG**	r = .13 p = .403	r = −.01 p = .941	r = −.14 p = .374	r = .14 p = .393
	VNG	r = .43 p < .006	r = .47 p < .002	r = −.02 p = .899	r = .38 p < .015
Narrative comprehension response time	**LNG**	r = −.27 p = .085	r = −.34 p < .033	r = .24 p = .136	r = −.16 p = .335
	VNG	r = .10 p = .527	r = −.06 p = .707	r = .60 p < .001	r = .04 p = .827

As in the VNG the narrative comprehension score positively correlated with age, CC and ToM, a multiple regression analysis that included the narrative comprehension score as dependent variable and age, CC and ToM scores as predictors was performed ($r = .60$; $r^2 = .36$; $r^2_{adj} = .30$; $F(3,36) = 6.67$; $p < .001$; $SE = .97$). From this regression it emerged that age ($\beta = .29$; $SE = 14$; $t(36) = 2.04$; $p < .049$) and CC score ($\beta = .31$; $SE = .15$; $t(36) = 2.07$; $p < .046$) significantly predicted the narrative comprehension score, while the ToM score was not significant ($\beta = .23$; $SE = .14$; $t(36) = 1.62$; $p = .113$) (see Table 4).

Table 4
Multiple regression model with the Narrative Comprehension score as dependent variable and Age, Central Coherence score and Theory of Mind as predictors in Visual narrative group.

	Multiple regression model	Narrative Comprehension score
	$R = .60$; $r^2 = .36$; $r^2_{adj} = .30$; $F(3,36) = 6.67$; $p < .001$; $SE = .97$	
Predictors	**Age**	$\beta = .29$; $SE = 14$; $t_{(36)} = 2.04$; $p < .049$
	Central coherence score	$\beta = .31$; $SE = .15$; $t_{(36)} = 2.07$; $p < .046$
	Theory of mind	$\beta = .23$; $SE = .14$; $t_{(36)} = 1.62$; $p = .113$

4. Discussion

The present study investigated the comprehension of narrative global coherence of written and visual stories in two groups of children with typical development aged from 8.00 to 10.11. The study had a twofold aim. First, to explore whether the understanding of narrative global coherence is affected by the different expressive medium used to convey a story; second, to explore the cognitive systems recruited for its comprehension in the two representational formats. Narrative comprehension was assessed by administering a task that required participants to arrange sentences, for children of the LNG, or pictures, for children of VNG, to construct a coherent story according to a given title. To investigate the possible cognitive underpinnings of narrative comprehension in the two expressive modalities, the two groups were also administered tasks aimed at assessing CC and ToM. Two main results emerged from the study. First, it was observed that the use of a different expressive code conveying narratives did not affect the overall comprehension performance: children of the LNG performed similarly to children of the VNG on the narrative task. Second, a different involvement of the cognitive skills assessed was found in the two tasks: CC and ToM scores positively correlated with narrative comprehension score only in the visual narrative comprehension task, and not in written one. Moreover, a regression analysis showed that two measures were able to predict the visual narrative comprehension score: CC and age.

Most of previous studies that investigated the effects of expressive system on children's story comprehension abilities compared monomodal – e.g., auditory-only or textual-only – and multimodal stories – e.g., auditory-and-pictures or pictures-and-texts (e.g., Boerma et al., 2016; Orrantia et al., 2014; Pike et al., 2010; Wannagat et al., 2021). At a general level, from these studies emerged that illustrations foster story comprehension when added to written or auditory texts. An investigation by Orrantia and colleagues (2014) explored children's ability to integrate the protagonists' actions with goals mentioned earlier in a story. Children were administered the stories in two conditions: an illustration presentation, in which the statements relating to the characters' goals were accompanied by a picture, and a text-only presentation with no illustration. In both conditions, the characters' actions could be either consistent or inconsistent with the previously stated goals. Results showed that 9-year-olds children were more able to detect the inconsistency when sentences were associated with illustrations than when the stories were presented in the text-only condition, thus supporting the view that the presence of pictures accompanying the stories facilitated making connections between characters' actions and their goals. Similar results were also obtained by Pike et al.,(2010) and Wannagat et al., (2021), who found that pictures facilitate inferences required to establish both local and global coherence, even when they do not explicitly depict the coherence-relevant information.

Differently from these studies, in the present investigation the two narrative conditions were both monomodal: as sentences in the written condition, pictures in the visual narrative comprehension task conveyed alone the whole content of the story. Therefore, the first result of our investigation, i.e., that children of the two groups obtained similar score on the two narrative comprehension tasks, provides new insight to the literature on the comprehension of narratives across different modalities. Specifically, it might offer empirical support to the criticism advanced by Cohn and Magliano (2020) towards the myth of transparency, i.e., the assumption of the universal transparency of sequential images. Such an assumption (often implicit, sometimes explicit) leads to the view that visual narrative comprehension is simpler than linguistic narrative understanding (Coderre, 2020). If this was the case, then our data should have shown significantly different scores in the two narrative tasks: children of the VNG should have outperformed children of the LNG on the arrangement narrative task. Such a difference was not observed. This suggests that illustrations may facilitate story comprehension only if they are added to written texts, in line with the so-called multimedia effect (Mayer, 2002; Schnotz, 2002; Schüler et al., 2015). When visual narratives are conveyed without the addition of words, they seem to be comparable in terms of comprehension performance to linguistic narratives. That said, it should be highlighted that the response time required to comprehend visual narratives was significantly lower than the response time taken to understand written stories. From this point of view, our results show that visual narratives, although not easier to understand than written stories, were less demanding in processing terms. This finding can be interpreted as indication that the comprehension of the two types of narratives involved different strategies. This leads us to the second result of the study concerning the cognitive underpinnings of narrative comprehension.

Although written and visual narratives were equally comprehensible by children, the cognitive abilities recruited for their comprehension were not the same. As shown by the correlations and regressions analyses, CC and ToM were differently involved in the narrative comprehension tasks. Specifically, it turned out that CC had a marginal role in the understanding of written narratives (it negatively correlated only with the narrative comprehension response time) but a major role in the comprehension of visual narratives (it was a predictor of the narrative comprehension score). To the best of our knowledge, this is the first study providing evidence of a relationship between CC and visual story processing. But this different involvement of CC in the two narrative conditions was an unexpected finding. In fact, the narrative task of the current study methodologically mirrored the task used by Jolliffe and Baron-Cohen (2000). As mentioned above, the authors explored the ability of adults with ASD to arrange written stories, suggesting that their impairment in coherently ordering sentences was due to their weak CC, which was therefore considered a requirement for processing the global coherence of written stories. On the basis of these indications, we expected to find a correlation between CC and both written and visual narrative comprehension scores. However, it should be observed that in the study by Jolliffe and Baron-Cohen (2000) participants (of both clinical and control group) were not administered a test aimed at directly assessing CC. The supposed relationship between global coherence of linguistic narratives and CC was based on the hypothesis that persons with ASD are thought to have weak central coherence. A study that directly assessed CC was carried out by Nuske and Bavin (2011), who investigated the comprehension of linguistic narratives in 4–7-year-old children with ASD and TD. To assess CC, the authors employed the Block Design sub-test from the WPPSI-3 (Wechslerm 2002) aimed at measuring the ability to analyze and synthesize abstract visual stimuli. As for the narrative task, children were required to read short stories and answer questions about their content. Results showed that, performance on Block Design significantly correlated with questions involving propositional inferential processing in ASD group, thus supporting the role of CC in integrating information for linguistic narrative comprehension. That said, it is possible that the absence of correlation between CC and the comprehension of written narratives in the present investigation might be related to methodological issues concerning the representational format of the CC task, that was presented in a visual modality. This implies that the CC task and the visual narrative task somehow rely on similar representational processes that might not be engaged in the same way in the written narrative task. As research indicates that the construction of a coherent mental representation of a story may engage both local processing and global processing depending on task and stimulus conditions (see Booth, 2006), understanding in which cases the creation of an integrated narrative representation relies on a predominant global processing style is an issue that needs to be further addressed.

Another interesting result of our study was that age and ToM correlated with the visual narrative comprehension score, but not with the written narrative one. The fact that age correlated and predicted children's performance on the visual narrative task is in line with previous studies that attested a developmental trajectory for when children begin to understand a sequence of images as a sequence (for a review, see Cohn and Magliano 2020). The absence of correlation between age and written narrative comprehension score might be explained by the complex dynamic relationship between reading development and narrative comprehension (Lynch et al., 2008). Each component skill involved in the two processes, as for example vocabulary progression, may well have a unique developmental path, which might influence the overall developmental sequence in different ways. This represents an interesting point that is worth exploring in future research.

The involvement of the ability to understand the feelings and emotions of others in the comprehension of visual narratives has been shown also in previous investigations, such as a study by Baron-Cohen and colleagues (1986), who explored the cognitive processes underlying the comprehension of picture stories employing an arrangement task like the one used in the current experiment (see also, Rhys-Jones and Ellis, 2000). Instead, the absence of correlation between written narrative comprehension score and ToM is at odds with previous research, which has revealed a development in children's narrative processing, both oral and written, that aligns with the progression of ToM across childhood (e.g., Dore et al., 2018; Kim, 2020; Kim et al., 2021). An investigation by Rall and Harris (2000) showed that 3 years old children are able to process stories from the spatial perspective of the character in a way that involves ToM. In their study, children heard narratives that included deictic verbs (*come, go*) that could be either congruent or incongruent with the protagonist spatial perspective. When asked to retell the story, children often changed the incongruent verb with the congruent one, indicating that they were monitoring the story from the character point of view . Consistently, Nyhout (2015) found that at the age of 7 children track characters' goals when listening to short narratives. Extending these observations to written texts, Dore et al. (2018) proposed that ToM is also crucial for understanding written narratives, thus contributing to the development of reading comprehension.

As the ToM task was presented in the visual modality, it cannot be ruled out the possibility that the reliance on the same expressive modality might account for a more significant involvement of ToM in the visual narrative condition compared to the written condition. However, it should be highlighted that fMRI studies revealed that ToM-related processes are independent of modality employed to present the stimuli (e.g., Gallagher et al., 2000; Kobayashi et al., 2007). Gallagher et al. (2000) investigated brain activation during two different tasks both designed to tap theory of mind: a linguistic task in which participants had to read short stories; a cartoon task in which participants had to watch pictures. Results revealed that the ability to mentalize was mediated by the medial prefrontal cortex and that this region was activated by ToM tasks regardless of modality. In the light of these considerations, a possible interpretation of the fact that in our study ToM ability correlated only with visual narrative comprehension score might be that our two narrative tasks might have elicited ToM with a different force. Indeed, the narratives we employed were not strictly mentalistic (e.g., they did not require the attribution of a false belief to the characters) but they only described/depicted interactions between two or more persons. In the written narratives, the feelings and emotions of the story characters were not explicitly stated in the text – mental state terms were absent; moreover, there was only one occurrence of a word describing an emotion (i.e., *angry*). On the contrary, in the visual narratives children could directly see the feelings and emotions of the story characters, which probably acted as clues to construct narrative coherence. In this vein, this result appears relevant as reveals that the activation of ToM might occur in different ways depending on different narrative situations and expressive modalities. This is a significant finding that is worthy being investigated in future research.

On the whole, the main finding that children performed similarly across the two narrative tasks seems to confirm the predictions of those accounts which confute the view that visual narratives are transparent and therefore easier to process compared to linguistic narratives. This result has important implications in the context of developmental and clinical research: it suggests that the naïve assumptions on the universal transparency of visual narratives – which lead educators and clinicians to prefer pictures in interventions designed to evaluate or promote narrative skills (e.g., Rozema, 2015) – may be misleading. At the same time, though, our results highlight that the processes underpinning story comprehension in written and visual modalities, although resulting in similar performances, do not completely overlap. It is worth highlighting that this does not entail that visual and linguistic narrative abilities are completely different from each other in terms of cognitive underpinnings. It is possible that further cognitive processes not explored in the present study, such as working memory and executive functions, are equally recruited to comprehend narrative across modalities, as suggested by previous investigations (e.g., Butterfuss and Kendeou, 2018; de Bruïne et al., 2021; Oakhill et al., 2005; Orrantia et al., 2014; Strasser and Río, 2014). Future research should provide a deep exploration of the cognitive and neural underpinnings of narrative in different expressive modalities to construct a more comprehensive framework of the various circumstances in which modality-specific aspects of narrative have an impact on its processing.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The current study involving human participants was approved by the ethical committees of

Roma Tre University and "Bambino Gesù" Children Hospital in Rome. Parents signed the consent form for the participation of their children to the study and for the treatment of the data.

Author contributions

IA planned the study, supervised the recruitment of the participants and the administration of the task, contributed the interpretation of the results, and wrote the paper. AC supervised the administration of the task, contributed to the interpretation of the results, and contributed to the writing of Introduction and Discussion. DA administered the tasks, processed the data, contributed to the interpretation of the results, and wrote results' section. VD recruited the participants and administered the tasks. CML recruited the participants and administered the tasks. AM supervised the recruitment of the participants, contributed to the interpretation of the results and to the final manuscript. GV supervised the recruitment of the participants. RM recruited the participants and administered the tasks. FF supervised the recruitment of the participants and the administration of the tasks, contributed to the interpretation of the results, and contributed to the writing of Introduction and Discussion.

Data availability

Data will be made available on request.

Declaration of competing interest

The authors declare that they have no conflict of interest.

Acknowledgments

We would like to thank the parents of the children involved in this study and the teachers of the "Istituto Comprensivo Via dei Sesami" (Rome) and "Istituto Comprensivo Corrado Melone - Plessi Odescalchi e Fumaroli" (Ladispoli) for their cooperation in recruiting the participants. We also thank "Edizioni Centro Studi Erickson" for the permission to use and adapt the materials employed for the narrative tasks.

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