Misrepresentation of science concepts in Turkish picture books

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Picture books are among the primary resources that could be referred to for introducing scientific concepts to young children. However, it is known that misrepresentations in picture books could lead to misconceptions in children and make it more difficult to acquire scientific concepts. This study investigates the misrepresentation of scientific concepts in illustrations and texts in picture books. The study sample included 117 books that focused on science concepts which were analysed for illustrations and texts. The data were collected with a book review form developed by the authors and analysed by inductive content analysis. Findings indicate that the books examined contained a large number of misrepresentations. The illustrations contained more misrepresentations in comparison to the texts. These misrepresentations were largely due to the use of anthropomorphism. Results are discussed in terms of misconceptions, concept acquisition and meaningful learning by children, and will contribute to the awareness of teachers, parents and persons concerned with children's literature about misrepresentations in picture books.

Introduction

Children are curious for scientific facts and knowledge when these concepts are presented in intriguing methods (Ellis, 2001). Picture books with developmental adequacy and scientifically accurate knowledge are effective instruments that help children understand their environment and connect with the natural world (Wells & Zeece, 2007). Picture books that bring science to life through these characteristics (Goins, 2004) are a good choice for the children to learn scientific concepts (Barclay, Benelli & Schoon, 1999; Ellis, 2001; Trundle & Troland, 2005). On the other hand, these books need to be selected carefully for children to learn events and concepts accurately (Eggerton, 1996; Royce & Wiley, 1996). This is because certain misconceptions by children about scientific concepts could be due to the picture books they have read (Ault, 1984). Trundle and Troland (2005) stated that reading books with misrepresentations could lead to misconceptions. Thus, it is essential for parents and teachers to pay attention while selecting picture books for preschool children in order to avoid possible misconceptions and for the picture books to fulfil their functions.

Picture books are among the initial resources utilised to introduce basic scientific concepts in preschool years. Picture books that stimulate children on emotional and intellectual levels and motivate them towards science are invaluable learning resources with creative illustrations, attractive photographs, the experiences and adventures of the protagonists, interesting stories and presentation of knowledge to encourage their curiosity (Ansberry & Morgan, 2007). Through these books, basic scientific concepts are structured in children's minds, conceptual learning is supported, and children's attention is enticed to motivate them towards science (Abell, 2008; Barclay et al., 1999; Mayer, 1995). In addition to this,

due to the fact that scientifically-accurate picture books do not solely focus on scientific content and science is presented as an endeavour in everyday life in these books (Goins, 2004), they contribute to the development of positive attitudes among children towards science (Madrazzo, 1997). Whether fiction or informative, these books that include scientific themes enable children to go beyond the classroom and experience several significant or insignificant natural phenomena that are not possible to observe directly in the classroom (Abell, 2008). Both types of books, however, need to contain accurate information in order to develop conceptual and processing skills about science in children (Barclay et al., 1999).

Teachers often use picture books to help children learn various scientific concepts (Barclay et al., 1999). There are some criteria that teachers who desire to benefit from picture books in science education should consider while selecting these books. These may be listed as books that avoid stereotypes, include accurate drawings, support scientific thinking and organise the scientific content correctly (Janke & Norton, 1983). Moreover, it is expected that the concepts focused in a scientifically-accurate books are distinguishable, the story is based on facts, and the reality in fiction is noticeable (Royce & Wiley, 1996). Mayer (1995) stated that effective science education could be conducted with illustrated books, but such books should not lead to prejudices, include accurate and realistic illustrations, and most importantly they would classify the scientific concepts accurately. Otherwise, these books could lead to misconceptions among children instead of learning the concept (Mayer, 1995).

Misconceptions about scientific concepts are often observed among preschool children (Mayer, 1995; Rice, Dudley & Williams, 2001). The most challenging aspect of the misconceptions that children experience in the learning process is that such misconceptions complicate the acquisition of new knowledge (Butler, Simmie & O'Grady, 2015). When incorrect information is stored in the brain, this could disrupt future learning processes (Gooding & Metz, 2011). Thus, existing misconceptions about concepts should be eliminated in order to learn new concepts accurately (Butler et al., 2015). However, it is quite difficult to overcome misconceptions to achieve the required conceptual changes (Cakir, 2008; van den Broek & Kendeou, 2008). Due to this resistance of misconceptions against change, scientifically-accurate resources should be used, to avoid leading children into misconceptions during their preschool period when scientific concepts are initially being introduced.

Selecting scientifically-accurate resources could be difficult for teachers with limited understanding of scientific concepts. Studies have demonstrated that preschool teachers' scientific content knowledge (Andersson & Gullberg, 2014; Kallery & Psillos, 2001) and conceptual understanding are very limited (Günay-Bilaloğlu, Aslan & Aktas-Arnas, 2008), and there are alternative concepts occurring frequently in their answers to children's questions (Kallery & Psillos, 2001). Furthermore, it is known that teachers often do not take the time to consider the accuracy of the information included in the books and they accept the content to be accurate (Sudol & King, 1996). Günay-Bilaloğlu et al., (2008) found that Turkish preschool teachers used books most frequently for scientific activity resources; however, mostly they did not question the information provided in these

books. Some researchers (Atkinson, Matusevich & Huber, 2009; Mayer, 1995; Sudol & King, 1996) have developed checklists for teachers to select the scientifically-accurate books, stating that teachers could assess the books using these checklists before reading them. These lists are useful for teachers with scientific content knowledge; however, they cannot fulfill their objective for teachers lacking in content knowledge (Crowson & Hopper, 2009).

Due to the fact that teachers might not have time and they might lack content knowledge for analysing children's books, it is important that the experts examine the books and provide information for teachers (Schussler, 2008). The list of *Outstanding science trade books for students K-12* is published each year in the United States by the National Science Teachers Association (NSTA) in collaboration with the Children's Book Council (CBC) to assist teachers in selecting books (NSTA, 2020). In Turkey, a list of recommended books that can be used in instruction in secondary and high schools was published by the Ministry of Education as *100 basic literary works* (Anonymous, 2005). However, the same publication mentioned that it was difficult to develop such a list due to the large number of available publications for preschool and primary school classes. Thus, there are no lists of recommended books for preschool children in Turkey. Both preschool teachers and parents are left without assistance in book selection, and they need support. For this reason, investigation of the scientific accuracy of picture books by experts can guide them to select suitable books with scientifically-accurate content for children.

While previous research generally focused on misrepresentations in science textbooks (Abimbola & Baba, 1996; Abraham, Grzybowski, Renner & Marek, 1992; Barrass, 1984; Barrow, 1990; Cho, Kahle & Nordland, 1985; Choi, Niyogi, Shepardson & Charusombat, 2010; Dikmenli, Cardak & Oztas, 2009; King, 2010; McComas, 1997; Storey, 1989; Weaver, 1965), a limited number of studies have addressed misrepresentations in picture books, mainly specific content such as the nature of science (Ford, 2006), the moon (Trundle & Troland, 2005; Trundle, Troland & Pritchard, 2008), plants (Goins, 2004), plant reproduction (Schussler, 2008), animals (Marriott, 2001), whales (Mayer, 1995), dolphins (Reiss, Sickler, Gruber, Boyle, Elliott, Lemcke, Fraser & Newman, 2006), and whales and dolphins (Beaumont, Mudd, Turner & Barnes, 2017). However, the literature review revealed no studies that investigated picture books published for preschool children on general science concepts, based on the misrepresentations they contained. Moreover, Rice (2002) examined the presentation of basic science concepts for the primary school level in children's books. The study reported that inaccurate information was provided in the illustrations and texts of the picture books about scientific concepts, several errors were noticeable in the content, and certain erroneous information was implicit in textual statements or illustrations.

As a result, in the process of acquaintance with science concepts, picture books which present interesting content through illustrations and texts, are often preferred by children, teachers and parents. Studies have demonstrated that illustrations and texts that could lead to misconceptions are often encountered in picture books (Mayer, 1995; Rice, 2002; Trundle & Troland, 2005). However, due to the lack of an official list of suggested books for preschool children in Turkey, the current situation with misrepresentation in picture

books is unknown. Considering that children acquire not only science concepts but also misconceptions from books, and that this makes it more difficult for them to learn scientific concepts accurately, it is necessary to prevent children from encountering such misrepresentations. Thus, this study aimed to investigate misrepresentations of scientific concepts in picture books that are published for preschool children in Turkey.

Method

Sample

The method of purposive sampling was used to identify the books that would be examined in the study. Merriam (2015) stated that criteria selection is important in determination of a sample by purposive sampling. Thus, the main criteria for the inclusion of the books were identified as the focus of the book content on scientific concepts and selection of fiction books. Based on these criteria, 152 illustrated children's books that were widely included in preschools and children's libraries, published by publishers with large sales and distribution networks, were reviewed by researchers. As a result of the review, 117 fiction books that focused on science concepts were included in the study sample. Decisions related to the books' focus on scientific content were based on the *National science education standards* (National Research Council, 1996) and *Next generation science standards* (National Research Council, 2013). Accordingly, the books were examined based on these standards: physical science, life science, earth and space science. The books in the study sample were evaluated based on illustrations and text.

Data collection and analysis

In order to investigate the representation of scientific concepts in picture books, these steps were followed: 1) accessing the books, 2) reviewing the books and 3) transformation of the obtained data into narrative descriptions, by grouping the data under important themes, categories and descriptive case examples (Patton, 2014). The researchers used book review form prepared by in line with the literature. This form included copyright information, the subject of each book, classification of the representations in illustrations and/or texts as accurate representations or misrepresentations, and examples of misrepresentation. To improve reliability, illustrations and texts included in the sample books were examined independently by three researchers (Miles & Huberman, 2015) and the data were individually used as input in the book coding form by each researcher. When the independently completed forms were combined, 132 illustrations and texts were coded. According to the reliability formula proposed by Miles and Huberman (1994) [Reliability = number of agreements / (number of agreements + number of disagreements)], it was determined that intercoder agreement was established at 85%. In the final stage, the researchers worked together on codes that were not present in coding forms where there was a disagreement. The books where there was a disagreement among the researchers were reviewed together by all until a consensus was reached, finding that 120 illustrations and texts contained misrepresentations.

Misrepresentations in book illustrations and texts were identified with the help of scientific databases such as the National Science Foundation, the Animal Research University of Cambridge, Oxford Plant Sciences, and TUBITAK National Observatory. Data analysis was conducted with inductive content analysis on the book illustrations and texts in the sample. In this direction, illustrations and text which are the research analytical units were classified based on the pre-constructed categories that were called scientific and non-scientific items. As a result of the analysis, the scientific and non-scientific illustrations and texts in the books and the distribution of the non-scientific items based on the categories and themes were determined. In the final stage of the inductive analysis, namely the validation phase, the data that did not fit the determined categories and themes or were outliers were carefully examined (Patton, 2014).

Regarding the codes, categories and themes that were collected in the study, views were obtained from five experts in the field of preschool science education and two experts in the field of science education. These experts were asked to evaluate the accuracy of the codes, categories and themes obtained within the scope of the research through an "expert opinion form" which was prepared by the researchers. Examination of the forms from the experts demonstrated that reached 83% agreement on codes for the illustrations, categories and themes, and 85% agreement on texts. It was therefore assumed that the findings were consistent (Miles & Huberman, 2015), and then, the editing work recommended by the experts for the points of disagreement was carried out. For example, the two categories named "natural assets" and "animals" were changed to "life sciences". The textual statement "presence of a tree in the Palmaceae family in desert climate" was considered as a misrepresentation in the study findings, but this finding was eliminated after expert advice that palm trees can occur in a desert environment. The code "bee making honey without honeycomb" encountered in both illustrations and text, was moved from "misrepresentations related to the temporal process of events" to the category "misrepresentations related to scientific accuracy". To give one more example, since an expert indicated that roosters can fly a short distance, the code "flying rooster" was reviewed again, to find that the illustrations in the relevant book showed the rooster flying close to the ground and for a short distance, so this code was removed from findings. After these kinds of reviews, the final data were quantified as frequency and percentage values (Figure 1). In addition to this, the books examined within the scope of the study were coded as B1, B2 ... Descriptions and direct citations are included to reflection the illustrations and texts in the books more clearly.

Results

The 117 books in the sample were categorised in three basic scientific content areas: "Life science", "Earth and space science", and "Physical science". Illustrations and texts in each book were examined independently. Findings are presented under two headings, "misrepresentations in illustrations" and "misrepresentations in texts".

Misrepresentations in illustrations

The illustrations in each book were analysed in two categories: accurate representation and misrepresentation. Accurate representation refers to the representations in the illustrations that are accepted by scientists, and misrepresentation refers to non-scientific aspects in illustrations. Figure 1 shows the frequency of accurate representations and misrepresentations in illustrations, for the three content areas.

Table 1: On the basis of book number distribution of the accurate representations/ misrepresentations in the illustrations according to scientific content areas

Life science Accurate representation (f=68, 88.3%) Misrepresentation (f=25, 62.5%)	Earth and space science Accurate representation (f=7, 9.1%) Misrepresentation (f=13, 32.5%)	Physical science Accurate representation (f=2 2.6%) Misrepresentation (f=2, 5%)
Characteristics of plants and animals Accurate representation (f=23, 29.9%) Misrepresentation (f=12, 30%)	Natural events Accurate representation (f=3, 3.9%) Misrepresentation (f=6, 15%)	Properties of objects and materials Accurate representation (f=1, 1.3%) Misrepresentation (f=1, 2.5%)
Life cycle of plants and animals Accurate representation (f=7, 9.1%) Misrepresentation (f=8, 20%)	Earth, Sun and Moon Accurate representation (f=1, 1.3%) Misrepresentation (f=6, 15%)	Colours Accurate representation (f=1, 1.3%) Misrepresentation (f=0, .0%)
Environment Accurate representation (f=10, 13%) Misrepresentation (f=4, 10%)	Seasons Accurate representation (f=2, 2.6%) Misrepresentation (f=1, 2.5%)	Time Accurate representation (f=0, .0%) Misrepresentation (f=1, 2.5%)
Food Accurate representation (f=2, 2.6%) Misrepresentation (f=1, 2.5%)	The cycle of day-night Accurate representation (f=1, 1.3%) Misrepresentation (f=0, .0%)	
Hygiene and health Accurate representation (f=21, 27.3%) Misrepresentation (f=0, 0%)		
Human body Accurate representation (f=5, 6.5%) Misrepresentation (f=0, .0%)		
Total Accurate representation (f=77, 65.8%) Misrepresentation (f=40, 34.2%)		

Overall, 34.2% of the books included misrepresentations. In the life science category, misrepresentations were most frequent in the topics of "characteristics of plants and animals" (30%) and "life cycle of plants and animals" (20%). In the physical science category, misrepresentations were most frequent in the topic "properties of objects and materials" (2.5%), whilst in the earth and space science category misrepresentations were most frequent in "earth, sun and moon" (15%), "natural events" and "time" (2.5%). However, no misrepresentations were observed in the topics of "hygiene and health", "human body", "the cycle of day-night", and "colours".

After determining the frequency of accurate representations and misrepresentations in the illustrations, misrepresentations were categorised into two types, "anthropomorphic misrepresentations" and "scientifically irrational misrepresentations." The frequency of anthropomorphic misrepresentations in illustrations is presented in Figure 2.

Table 2. Distribution of anthropomorphic misrepresentations in illustrations

Theme	Category	Code	*f*	%
Anthropomorphic misrepresentations (*f*=59, 81.9%)	Earth and space science (*f*=33, 45.8%)	Drawing a face on the Sun	17	23.6
		Drawing a face on the Moon	4	5.6
		Drawing a face on the Earth	3	4.2
		Drawing a face on the clouds	3	4.2
		Drawing a face on planets	2	2.8
		Drawing a face on the stars	2	2.8
		Drawing a face on the soil	1	1.4
		Drawing a face on the mountains	1	1.4
	Life science (*f*=26, 36.1%)	Drawing a face on the plants	8	11.1
		Drawing hands and fingers on insects	6	8.3
		Inaccurate posture with body structure of animals	6	8.3
		Drawing distinct eyelash on female animals	3	4.2
		Drawing hands on mouse	1	1.4
		Drawing hair on turtle	1	1.4
		Drawing hands and fingers on penguin	1	1.4

Figure 2: Frequency of anthropomorphic misrepresentations in illustrations

Anthropomorphic misrepresentations were identified in earth and space sciences (45.8%) and life sciences (36.1%). In earth and space sciences these were in the form of the transfer of human characteristics to earth and space sciences elements, with the most common being "drawing a face on the Sun" (23.6%). In the life sciences category, the most common anthropomorphic misrepresentations were "painting a face on plants" (11.1%), "drawing hands and fingers on insects" (8.3%) and "inaccurate stature of animals" (8.3%).

The frequency of scientifically irrational misrepresentations in illustrations is presented in Table 3.

Table 3: Distribution of scientifically irrational misrepresentations in illustrations

Theme	Category	Code	*f*	%
Scientifically irrational misrepre-sentation (*f*=13, 18.1%)	Earth and space science (*f*=7, 9.7%)	Illustration of the stars with a five point star drawing	4	5.6
		The peaks remaining green while snowing	1	1.4
		The daisy growing on glaciers	1	1.4
		Non-scientific illustration of snowflakes	1	1.4
	Life science (*f*=6, 8.3%)	The crocodile swimming with strikes	1	1.4
		Bee making honey without honeycomb	1	1.4
		Sudden growing of a small fish	1	1.4
		The roots of the unrooted trees not containing any soil on them	1	1.4
		Non-anatomical illustration of heart	1	1.4
		New-born penguin having long pile	1	1.4

Overall, 18.1% of the illustrations included scientifically irrational misrepresentations. Of these, 9.7% were in the earth and space science category, and 8.3% were in the life science category. The most common misrepresentation in the earth and space science category was "illustration of the stars with a five-point star drawing" (5.6%). The most striking examples in the life sciences category were "crocodile swimming with strokes" (B29), and "the roots of uprooted trees not containing any soil on them" (B71).

Misrepresentations in text

The texts were reviewed in two categories, accurate representation and misrepresentation. The term 'accurate' refers to representations in texts that are accepted by scientists, and 'misrepresentation' refers to non-scientific statements of facts in texts. The frequency of accurate presentation and misrepresentation in the texts according to content areas is presented in Table 4, for the three content areas.

21.4% of the books contained misrepresentations in the texts. The highest number of misrepresentations was observed in the "life science" category (52%), most frequently in the topics of "characteristics of plants and animals" (24%) and "life cycle of plants and animals" (16%). In the category of earth and space science, we identified the highest number of misrepresentations on the topic of "natural events" (24%). We could not identify any misrepresentations in the topics of "hygiene and health", "human body", "the cycle of day-night", "colours" and "time" in the texts.

Misrepresentations in the texts were classified under three themes, "misrepresentations of causality" (31.8%), "misrepresentations of temporal process of events" (11.4%), and "misrepresentations of scientific accuracy" (56.8 %) (Table 5).

Table 4: On the basis of book number distribution of the accurate

Life science Accurate representation (*f*=80, 86.6%) Misrepresentation (*f*=13, 52%)	Earth and space science Accurate representation (*f*=9, 9.8%) Misrepresentation (*f*=11, 44%)	Physical science Accurate representation (*f*=3, 3.3%) Misrepresentation (*f*=1, 4%)
Characteristics of plants and animals Accurate representation (*f*=29, 31.5%) Misrepresentation (*f*=6, 24%)	Natural events Accurate representation (*f*=3, 3.3%) Misrepresentation (*f*=6, %24)	Properties of objects and materials Accurate representation (*f*=1, 1.1%) Misrepresentation (*f*=1, 4%)
Life cycle of plants and animals Accurate representation (*f*=11, 12%) Misrepresentation (*f*=4, 16%)	Earth, Sun and Moon Accurate representation (*f*=3, 3.3%) Misrepresentation (*f*=4, 16%)	Colours Accurate representation (*f*=1, 1.1%) Misrepresentation (*f*=0, .0%)
Environment Accurate representation (*f*=12, 13%) Misrepresentation (*f*=2, 8%)	Seasons Accurate representation (*f*=2, 2.2%) Misrepresentation (*f*=1, 4%)	Time Accurate representation (*f*=1, 1.1%) Misrepresentation (*f*=0, .0%)
Food Accurate representation (*f*=2, 2.2%) Misrepresentation (*f*=1, 4%)	The cycle of day-night Accurate representation (*f*=1, 1.1%) Misrepresentation (*f*=0, .0%)	
Human body Accurate representation (*f*=5, 5.4%) Misrepresentation (*f*=0, .0%)		
Hygiene and health Accurate representation (*f*=21, 22.8%) Misrepresentation (*f*=0, .0%)		
Total Accurate representation (*f*=92, 78.6%) Misrepresentation (*f*=25, 21.4%)		

Table 5. Distribution of misrepresentations of causality in texts

Theme	Category	Code	*f*	%
Misrepresentations of causality (*f*=14, 31.8%)	Atmospheric phenomena (*f*=5, 11.4%)	The cloud hanging in the sky as a result of its light	1	2.3
		Hot wind occurring as a result of the combination of sun and wind	1	2.3
		The fog occurring as a result of the cloud coming down to see the children	1	2.3
		Clouds moving because they escape from the Sun	1	2.3
		Rain occurring because the porcupine riddled the clouds with its quills	1	2.3
	Earth, Sun and Moon (*f*=4, 9.1%)	Lunar eclipse occurring as a result of the Sun's anger	1	2.3
		Solar eclipse occurring as a result of the Moon's jealousy	1	2.3
		Seasons occurring as a result of the Sun's bringing	1	2.3
		The air cooling as a result of the Sun dimming its light	1	2.3
	Natural disasters (*f*=3, 6.8%)	Lavas flowing as a result of the volcano's sneezing	1	2.3
		The mountain turn into a volcano as a result of being sick	1	2.3
		Earthquake occurring as a result of the anger of land	1	2.3
	Sound-Light (*f*=2, 4.6%)	The sound is heard higher as a result of darkness of the ambient	1	2.3
		Shadow not seeing in the glaciers as a result of being white around	1	2.3

The highest number of misrepresentations of causality in the texts was about atmospheric phenomena (11.4%). For example, formation of rain was explained in relation to the protagonist of the book as follows: "…the porcupine pointed its quills when he arrived at the top of the hill. It jumped with all its might, jumped five times and riddled the clouds with holes. And through these holes came the rain pouring" (B75). Similarly, formation of fog was associated with the descent of the cloud, the book's protagonist, to the earth after seeing the children: "...the cloud saw the children playing below during its promenade. It was delighted. It descended to the ground laughing. But, everywhere was covered by the fog..." (B105). The statements "...the clouds quickly moved away from the sun. They went and went and went... They stood at a place far away from the Sun where they could no longer see it" (B72) emphasised that the reason for the movement of the clouds was to escape from the sun.

In the texts, certain misrepresentations associated with causality were related to the earth, the sun and the moon (9.1%). The most significant examples included the explanation of the solar and lunar eclipses with friendship relations rather than scientific causality. One of books explained the solar eclipse with the jealousy of the moon. The moon complained as follows:

> The moon thought 'They do not even notice me... The earth always plays with the sun. Nobody likes me'. It was very jealous about them. And it had an idea. It decided to enter between the earth and the sun to attract their attention (B65).

In another book, it was stated that lunar eclipse was due to the anger of the Sun: "The sun also got help from the earth. During the days when the moon was boasting, it made the moon lose its glare. It made the moon invisible" (B103).

Various non-scientific explanations about the causes of natural disasters in the texts were determined (6.8%). For example, in a book about the formation of a volcano the mountain became a volcano because it was ill: "...one day the mountain had severe stomach pain. It started to run a fever as well. Its cheeks became pink. It realised that it became really ill." When the ill mountain sneezed, the lava poured out of it: "…and, it sneezed, unable to hold it. All the lava came out when it sneezed." (B67).

Another natural disaster, an earthquake, was also misrepresented in the books. In a book that described the formation of an earthquake, it was emphasised that when the soil expressed temper, everywhere shook and that is how the earthquakes were formed: "...when the aunt soil heard these words, it became so nervous… It began to tremble with anger. Everywhere was shaking, animals were running away..." (B71).

Certain causal misrepresentations were associated with sound-light topics (4.6%). The reason for increased volume of sound in dark environments was explained as follows: *"In a dark space, any sound is heard as loud by the ear"* (B50). However, the loudness of the sound is related to the volume of the sound, in other words, sound waves. Similarly, a book stated that the shadows cannot be seen due to the white colour of the glaciers as follows: *"...did you notice, when everywhere is white, you cannot see your shadow?"* (B50).

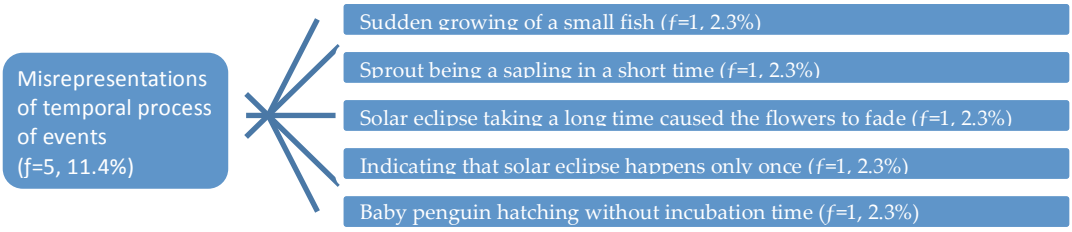

Figure 6: Frequency of misrepresentations of events in texts, based on temporal process

In the texts, several misrepresentations about the temporal courses of events were identified (11.4%) (Figure 6). For example, an extended solar eclipse that caused flowers to fade was narrated as follows: "...all living beings need the Sun. See how the flowers and the trees began to fade, do you see, he said". In a book that addressed a solar eclipse, it was stated that the eclipse only occurs once: "...from that day on, one side of the Earth was sunny, and the other side was with the moon and stars" (B65).

Finally, a part of the misrepresentations in texts found in the sampled books was due to scientific inaccuracy (Figure 7).

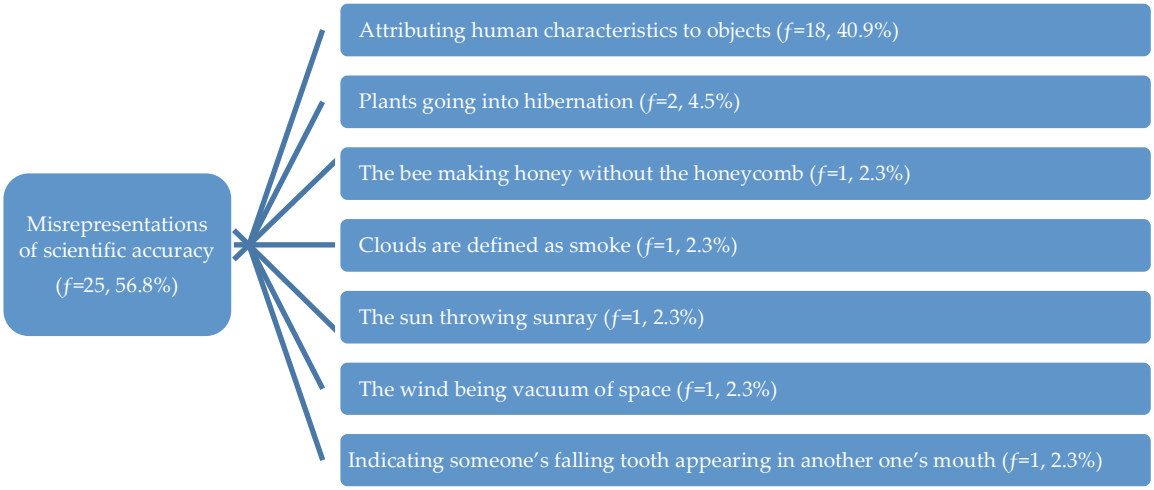

Figure 7: Distribution of misinterpretations associated with scientific inaccuracy in texts

The highest number of misrepresentation of scientific accuracy found in the texts was related to "attributing human characteristics to objects" (40.9%). Attribution of a human smile to the moon and the stars was stated as follows: "...The moon and several little and big stars smiled at him" (B5), while the sleeping behaviour that is specific to humans and animals was attributed to the plants and inanimate beings such as the sun and the stream:

> ... The sun was awake and shining… The stream in the forest was still asleep... Even the grass that slept all night woke up... The trees were awake, the flowers were awake... (B49).

Furthermore, in the books in the sample, a vitality that was attributed to the earth and celestial bodies was stated as follows:

> The Earth: Every day, I breathe harder and harder [coughing hard] … If the humans will not fulfill their responsibilities, I will get sick (B10);
> ... the sun, the moon, the stars, the clouds and the wind lived together in the sky (B68);
> ... two cheerful clouds lived in the sky..." (B72).

Another misrepresentation about scientific accuracy that was found in the reviewed books was attribution of human qualities to animal characters. The anthropomorphism effect was observed on the vital properties of animals such as feeding, finding shelter, sleeping and spending time in different ways. This was exemplified by wild animals drawing pictures (B23), playing musical instruments (B25), living in houses similar to those humans inhabit, and using objects specific to human use (B58).

In addition to anthropomorphism, the most significant examples of misrepresentation that were scientific inaccuracies were hibernating plants (B3) and identification of the clouds as smoke (B35). In one book, the sun was launching beams:

> ... it rerouted one of its beams quickly and launched it towards Kimi. The sunbeam hit Kimi's tail first, then it jumped on his back and exploded like a thunderbolt on his head (B49).

Discussion

This study aimed to investigate misrepresentations of scientific concepts in picture books published for preschool children. Although the number of picture books on scientific topics or concepts has increased in Turkey in recent years, the findings show that these books contained significant misrepresentations.

The illustrations in the books included more misrepresentations in comparison to the texts. In the picture books, the relationship between the illustration and the reference that leads to it is a critical characteristic that could impact the learning of children. This is related to the realistic or fantastical portrayal of the objects in the illustrations in picture books. Many picture books for children can depict reality in a distorted way using fantasy elements (Ganea, Canfield, Simons-Ghafari & Chou, 2014). Factors such as the pictures in the books being realistic or having iconic drawings affect children's processes of acquiring information and transferring knowledge. Accordingly, as the similarity between the illustration in the book and the referenced resource increases, the transferability of the knowledge on the concept increases as well (Ganea, Pickard & DeLoache, 2008; Simcock & DeLoache, 2006; Tare, Chiong, Ganea & DeLoache, 2010). Hibbing and Rankin-Erickson (2003) stated that illustrations in books may help the comprehension of the book content in cases like limited vocabulary, insufficient knowledge on the subject, and lack of comprehension of the relationships that are represented in the text. For preschool children who still cannot read or write, illustrations are as important as the story itself (Dağlıoğlu & Çakmak, 2009). Since scientific concepts are introduced to children through picture books (Trundle, Troland & Pritchard, 2008), the illustrations in such books are of critical importance. Children often want books that attract their attention to be read over and over again. Repetitive reading of books with scientifically inaccurate content would cause the child to be exposed to misinformation several times. However, minor changes on the illustrations of the story, for example, providing an accurate number of wings of the butterfly in the story of the metamorphosis of a caterpillar into a butterfly, would not change the storyline, while it would enable children to reach accurate information several times, which contributes to children's understanding of the natural world (Beaumont et al., 2017).

The books included in the sample were divided into three categories as life sciences, earth and space sciences and physical sciences in terms of the science subjects they focused. Then illustrations and texts in each book were evaluated according to the inclusion of misrepresentation and accurate representation. The findings demonstrated that, although there were several books on hygiene and health issues in the life science category, they did not include illustrations or texts with misrepresentations. Thus, they contained highly scientific content. Consistent with the characteristics of the preschool period, the books predominantly focused on concepts such as family, health, nutrition and hygiene, which are closely associated with a child's daily life (Erdal, 2008; Nas, 2006). Furthermore,

previous studies demonstrated that books on health play a positive role in raising children's awareness of (Droog, Buijzen & Valkenburg, 2014; Droog, van Nee, Govers & Buijzen, 2017; Goldman & Descartes, 2016). Similarly, Erdal (2008) examined numerous picture books that aimed for children to acquire the habit of hygiene and determined that these books mostly had adequate characteristics as children's books.

This study found that anthropomorphism was utilised in the majority of illustrations and texts that included misrepresentations. Human qualities were attributed to the earth and celestial bodies, animals and plants by drawing a face, a hand, a finger on these objects that are similar to human organs. Representations were found where wild animals lived in homes similar to those of the humans, painted pictures, and played musical instruments. Consistent with our research findings, Marriott (2002) determined that, in picture books, animals were characterised with typical human qualities such as having names, attending school, living in a home, and talking to other characters.

However, there are different views on the effects on children's conceptual knowledge of using anthropomorphic elements to describe objects. While several authors and educators considered that anthropomorphism reinforces misconceptions among young children, others suggested that this technique facilitates learning, believing that abolishing the use of anthropomorphic elements would deplete children's literature (Ansberry & Morgan, 2007). Aligning with the former view, Legare, Lane and Evans (2013) stated that the stories using anthropomorphic language and designed to explain evolutionary concepts distanced children from scientifically accurate interpretations, and although anthropomorphic language is interesting, it might enforce anthropomorphic misconceptions. Similarly, Ganea et al. (2014) determined that anthropomorphic illustrations and language used in books adversely affected children's comprehension of information about animals. The second view, that anthropomorphism helps children's literature to be attractive, recognises that anthropomorphic elements might lead to misconceptions, but these misrepresentations can be transformed into acceptable conceptions through the use of different strategies since they nurture the attention of children for books (Ansberry & Morgan, 2007; Benchmarks for Science Literacy, 2009; Gomez-Zwiep & Straits, 2006; Trundle et al., 2008). Benchmarks for Science Literacy (2009) suggested that anthropomorphism embedded in stories might lead to concerns on providing inaccurate information; however, the human qualities attributed to plants and animals in stories could be accepted for the purpose of sustaining children's interest in reading books.

The findings demonstrated that certain misrepresentations in the sampled books were due to inaccurate causality. Statements that could lead to misconceptions about atmospheric events, earth, sun and moon, natural disasters and sound-light concepts were determined. Some texts demonstrated statements loaded with emotions such as anger, jealousy and nervousness about the causes of the events, and statements such as lava flowing as a result of the volcano's sneezing, clouds moving because they escape from the sun, rain occurring because the porcupine riddled the clouds with its quills, were used in an attempt to concretise the events. This may be interpreted as the authors presenting reasons for events in a way that children can understand, given the limitations of preschool children in

rational thinking. Anthropomorphic elements were often included in the misconstruction of cause and effect relationships. Attribution of human qualities such as motivation, purpose and behaviour to different events and beings could lead to confusion (Plummer & Kuhlman, 2008). Rice et al. (2001) reported that children's misconceptions about scientific concepts could be due to books that contain inaccurate and confusing information. In the preschool period, which is critical for the development of cause and effect relationships (Bullock & Gelman, 1979; Drayton, Turley-Ames & Guajardo, 2011; Harris, German & Mills, 1996; Schlottmann, 2001), when it is considered that science is initially introduced to the children through books (Barlow, 1991), providing unscientific explanations to explain the causes of natural events could lead to profound misconceptions among children.

Some misrepresentations that were identified in this study arose from attribution of unnatural features to living beings and nature. Such content could lead to misconceptions among children, for example from illustrations of animals with features they do not possess, of plants out of their natural habitat, and of natural events and celestial bodies with qualities that they do not possess. Rice (2002), who investigated 50 children's books that included scientific themes, found that these books included inaccurate illustrations and texts about living beings and nature such as misnaming animal species, exaggerated and misrepresented discoloration of chameleons, presence of swamps only in forests, and considering fungi as plants. Reiss et al. (2006), who investigated the presentation of dolphins in popular media such as children's books, movies and TV shows, emphasised that positive or negative exaggerated presentation of dolphins in popular culture could make it difficult for the child to separate the reality and the fiction, and this could create an obstacle in science education. The misrepresentation of animal characters in stories leads to impossible expectations about animals among children (Anderson & Henderson, 2005). Although it is important that books should encourage children's imagination, it is not appropriate for children to think that an animal that eats a fish is an herbivore or a dolphin has no blow hole (Beaumont et al., 2017). Thus, it should not be forgotten that every piece of misinformation presented in picture books about the concepts that children frequently encounter in their everyday lives during the preschool period could make it difficult for children to recognise their environment, and negatively affect the structuring of new information (Butler et al., 2015). Mayer (1995) also stated that visuals and texts that contain misrepresentations in picture books may lead to confusion among children and inhibit the learning of scientific concepts. Thus, carelessly selected children's books could lead to misconceptions among children as well as being an ineffective resource for science education.

When selecting high qualitybooks for science education, great attention should be paid to the accuracy of information included in the illustrations and content (Rice et al., 2001). Thus, authors and illustrators should prioritise providing accurate information in their books (Beaumont et al., 2017). For this, the scientific background of book authors and illustrators is important (Pringle & Lamme, 2005). This does not guarantee the accuracy of the book content (Short, 2010), it would reduce the number of misrepresentations in such books. Strengthening the relationship between author and illustrator is considered to be an important step towards reducing these mistakes (Beaumont et al., 2017). Trundle et al.

(2008) stated that mistakes in the illustrations and the content of children's books may be caused by authors and illustrators of children's literature working independently of each other. Illustrators who are presented with the written text may attempt to interpret it visually, while the authors may make insufficient contributions to this artistic process. If good liaison between author and illustrator is lacking, visual misrepresentations could accompany scientifically accurate texts, and vice versa.

Conclusion and suggestions

Results revealed that many Turkish picture books for preschoolers misrepresent scientific concepts. Illustrations in the books included more misrepresentations compared with the texts. Most of the misrepresentations in illustrations and texts included anthropomorphism. The most prevalent misrepresentations were observed in the life science category, with the fewest misrepresentations observed in the hygiene and health category.

Teachers should act sensitively over using picture books in preschool science education. Books should be carefully checked by the teacher during selection, and books that contain non-scientific illustrations and texts should be discarded. Furthermore, checklists that could guide teachers in selection of scientifically-accurate books should be developed, and teachers encouraged to review books using criteria included in these lists. Misrepresentations in books that are already in classrooms can be turned into a learning opportunity by the teachers. In this context, scientific concepts acquired by the students through concrete learning experiences can be compared to the misrepresentations in the books (Trundle & Troland, 2005) for acquisition of concepts and meaningful learning. For this purpose, teachers should possess good scientific and pedagogical content knowledge, to facilitate selecting scientifically-accurate books and creating educational opportunities when using books containing inaccurate content. A commission of field experts, publishing houses, authors and illustrators could find a common ground for creating a list of recommended picture books. This way, parents and teachers can more readily books with accurate content. As a result, use of scientifically-accurate books can be encouraged in preschool science education, and the potential misconceptions that could arise due to the book content could be avoided.

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