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US and Turkish preschoolers' observational knowledge of astronomy

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ABSTRACT
The purpose of this cross-cultural study was to describe and compare US and Turkish children's observational knowledge of the day and night cycle and to identify similarities predicted by framework theory. Fifty-six (27 US and 29 Turkish) young children (ages 48–60 months) participated in the study. Semi-structured interviews were individually conducted, digitally recorded, transcribed, and analyzed using the constant comparative method. The results demonstrate that preschoolers from the two cultures are able to make comparable informal observations of the sky, and their observational knowledge includes many similarities, with one exception, as predicted by framework theory. US children were more likely to perform better than the Turkish children on the question about the time of observation for the moon. Although science concepts and skills are better represented in US early childhood education programs than the Turkish program, the results suggest that this advantage did not translate into performance differences between US and Turkish children.

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Introduction

Young children can be fascinated by the day and night skies. This interest leads children to make observations of celestial objects and events early in their everyday lives (Kallery, 2011). Two major competing explanations exist in the literature regarding how children interpret and represent their observational knowledge: framework theory (Vosniadou & Brewer, 1992) and knowledge in pieces theory (diSessa, 1993). The former explanation suggests that presuppositions (e.g. physical objects are solid, stable, and fall if unsupported) influence children's interpretations of their everyday observations of day and night skies (Vosniadou & Brewer, 1994; Vosniadou, Vamvakoussi, & Skopeliti, 2008). Children use these interpretations or beliefs as a basis for the construction of mental models of astronomy phenomena, which are coherent mental structures (Vosniadou & Brewer, 1992, 1994). The latter explanation, proposed by diSessa (1993), challenges the notion of coherent cognitive representations and suggests that cognitive representations

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consist of fragmented knowledge pieces that might be highly inconsistent with each other (diSessa, Gillespie, & Esterly, 2004). diSessa (1993) coined the term 'phenomenological primitives' to refer to fragmented knowledge pieces that are mostly accumulated through everyday experiences. diSessa (2002) also coined the term 'coordination classes' which he posits guide individuals to interpret novel information using contextual clues.

Although a body of research studies has been generated utilizing the framework theory on children's understandings of the day and night cycle, these studies have examined the type of mental models children have regarding the mechanism of the day and night cycle and were typically conducted with children in early and upper elementary grades (Diakidoy, Vosniadou, & Hawks, 1997; Samarapungavan, Vosniadou, & Brewer, 1996; Valanides, Gritsi, Kampeza, & Ravanis, 2000; Vosniadou & Brewer, 1994; Vosniadou, Skopeliti, & Ikospentaki, 2004). The content of young children's observational and cultural knowledge, on the other hand, has not been targeted in the literature, and this study aims to address this gap in the literature. Children's observational and cultural knowledge are constrained by domain-specific presuppositions and serve as the basis for the formation of mental models. Framework theory suggests that domain-specific presuppositions that influence children's observations might be universal because children typically share similar observational experiences (Vosniadou, 1994). Thus, regardless of where they live children should develop similar mental models of the day and night cycle (Vosniadou & Brewer, 1994). By examining both US and Turkish children, we can gain greater insights into children's observational experiences and understandings across cultures.

The Turkish early childhood education program included in the current study is a developmental program that targets self-care skills as well as the socio-emotional, cognitive, motor, and language development of children (Milli Eğitim Bakanlığı [MEB], 2012). Unlike US preschool and kindergarten programs where developing conceptual understandings of foundational science concepts in children are targeted, the Turkish program does not include early science learning content standards for the preschool and kindergarten level (Saçkes, Flevares, & Trundle, 2010; Saçkes, Trundle, & Flevares, 2009). The Turkish program only makes weak references to the development of some science process skills (i.e. making observations and establishing a cause and effect relationship) (Saçkes, 2014a).

Previous research studies indicated that in typical US and Turkish preschool and kindergarten classrooms very little time is devoted to support children's learning of science concepts and skills (Early et al., 2010; Saçkes, 2014b; Saçkes, Trundle, Bell, & O'Connell, 2011; Varol, 2013). When US and Turkish early childhood educators attempt to introduce science concepts and skills they mostly focus on specific life and space science concepts and employ instructional strategies that are not aligned well with contemporary science education literature (Ayvacı, Devecioğlu, & Yiğit, 2002; Güler & Bıkmaz, 2002; Saçkes, 2014b; Trundle & Saçkes, 2012). Therefore, we expect that differences between US and Turkish early education programs will not translate into performance differences between US and Turkish children.

The present study aims to examine the observational knowledge of young children, which subsequently serve as the basis for the development of mental models of the day and night cycle, from two cultures to identify whether US and Turkish children have similar observational knowledge as predicted by the framework theory. More specifically, the current study seeks to answer the following research questions: What do US and

Turkish children know about the objects in the sky? Do US and Turkish children have similar observational knowledge of astronomy? Does their knowledge of objects in the sky differ by gender?

Children's understandings of observational astronomy

A large body of research on young children's ideas of astronomy has been generated (Lelliott & Rollnick, 2010; Saçkes, 2015a). Most studies in the literature have focused on children's understanding of the shape of the Earth, day and night cycle, seasons, and lunar concepts. The current study focuses on the concepts of celestial objects that are observable by young children in the day and night skies. Therefore, a brief presentation of the literature concerning children's understandings of the day and night cycle and lunar concepts is provided below.

Day and night cycle

Most adults understand that the Earth's rotation on its axis causes the day and night cycle. However, this scientific understanding is not held by most young children who hold alternative ideas about the cause of this familiar natural phenomenon. Research studies with young children have demonstrated that most tend to perceive the sun's movement across the sky as the cause for the day and night cycle (e.g. Küçüközer & Bostan, 2010; Piaget, 1972; Sharp, 1996; Siegal, Butterworth, & Newcombe, 2004; Tao, Oliver, & Venville, 2012; Valanides et al., 2000). Some children proclaim it is the deviation in the sun's strength, which causes the day/night cycle, and they believe that the sun is strong during the daytime and its strength diminishes by the end of the day (Kallery, 2011). Others relate the cause of the day/night cycle to the movement of the moon. These children believe that when there is no moon in the sky we experience daytime and when the moon is up it is nighttime (Küçüközer & Bostan, 2010). Other common misconceptions of young children through later elementary ages include the blocking of sunlight by clouds or the movement of the Earth around the sun as the cause of the day and night cycle (Baxter, 1989; Kikas, 1998; Küçüközer & Bostan, 2010; Siegal et al., 2004). This latter misconception appears to be a synthesis of scientific knowledge provided in school with intuitive ideas, and it was found to be popular with older elementary English, Greek, Estonian, and Turkish students (Baxter, 1989; Kikas, 1998; Küçüközer, Korkusuz, Küçüközer, & Yürümezoğlu, 2009).

The concurrent movement of the Earth on its own axis and in an orbit around the sun appears to be unclear for many young children (ages 5–6), and this lack of clarity on these concepts can be a factor in the construction of this particular alternative conception (Saçkes, 2015b; Valanides et al., 2000). Supernatural forces or anthropocentric explanations are often provided by a few children as the cause of day and night. These children believe that daytime occurs for the purpose of work and school while nighttime happens to allow us to sleep (Küçüközer & Bostan, 2010; Tao et al., 2012). For these children, human activities cause the day and night cycle.

Under the constraints of framework theory, researchers have reported that children can hold different mental models of the day and night cycle, which are influenced by their everyday experiences and intuitions (Vosniadou & Brewer, 1994). Younger children who hold naïve or initial models tend to believe that day and night are caused when the sun moves toward or away from the Earth. Others think that Earth's physical attributes or the atmosphere (i.e. clouds) block the sun to cause night (Saçkes, 2015b; Vosniadou & Brewer, 1994). However, older children usually possess one of the following synthetic models, which combine scientific knowledge with intuitive ideas, to explain day and night: (1) the sun and the moon orbit the stationary Earth each day, (2) the Earth and the moon orbit the sun each day, (3) both the moon and sun travel in up and down directions while both are situated on different sides of the Earth, or (4) the sun and the moon are in fixed positions on the opposite sides of the Earth and the Earth rotates in either an up and down or east to west direction. Some of these synthetic models are similar to ones previously identified in the literature (Baxter, 1989; Kikas, 1998; Küçüközer et al., 2009).

Similar models were also identified in other studies with children from different cultural backgrounds (Diakidoy et al., 1997; Dunlop, 2000; Samarapungavan et al., 1996; Vosniadou et al., 2004). For example, the movement of the Earth around the sun as the cause of day and night was the most common alternative explanation held by older Greek children. Younger Greek children believed clouds or mountains block the sun to cause night (Vosniadou et al., 2004). The majority of Australian children (ages 7–14) reasoned that the day and night cycle results from the Earth's daily orbit of the sun or that the moon blocks the sun (Dunlop, 2000). While American-Indian and Indian children held mental models of the day and night cycle similar to European-American children, they also held some culture-specific mental models (Diakidoy et al., 1997; Samarapungavan et al., 1996). American-Indian children held culture-specific conceptions reflecting their cultural creation myth while Indian children seemed to be influenced by Indian mythology. For example, young Indian children believed that the Earth is positioned on top of a body of water, and the sun and the moon go down into the water underneath the Earth to cause day and night (Samarapungavan et al., 1996). Results from these studies in different cultural contexts indicated that younger children were more likely to hold intuitive mental models of the day and night cycle whereas older children were more likely to hold synthetic and scientific mental models.

In another more recent study, Tao et al. (2012) investigated eight-year-old Chinese and Australian children's ideas on the day and night cycle. Most Chinese children explained the cause of the day and night cycle by providing a description of their observations. Children associated the appearance of the sun with the day sky and the moon and the stars with the night sky, and they attributed the cause of day and night to the presence or absence of these celestial objects. A few children from each culture used the rotation of the Earth as an explanation for the day and night cycle. The motion of the sun around the Earth or behind the moon were other common explanations Chinese and Australian children provided for the day and night cycle (Tao et al., 2012).

Lunar concepts

Studies on children's understanding of lunar concepts demonstrate that the majority of the children, even at the early ages, are cognizant of the moon's changing appearance over time (Piaget, 1972; Plummer, 2009; Za'rour, 1976). The majority of children reason that the moon is observable only in the nighttime sky and few are aware that the moon also appears in the daytime sky (Doğru & Şeker, 2012; Hobson, Trundle, & Saçkes, 2010; Küçüközer & Bostan, 2010; Plummer & Krajcik, 2010; Trundle, Saçkes, Smith, & Miller, 2012).

Children commonly use various analogies to describe the different shapes of the moon (Haupt, 1950; Küçüközer & Bostan, 2010; Trundle, Atwood, & Christopher, 2007; Za'rour, 1976), and children are more aware of some phases (e.g. full moon, crescents, and the waning phases of the moon) than other phases (e.g. gibbous moon) (Doğru & Şeker, 2012; Hobson et al., 2010; Trundle et al., 2007). Children's representations of the moon typically include nonscientific shapes, such as an exaggerated or overarticulated crescent moon or banana, to represent different phases of the moon (Doğru & Şeker, 2012; Hobson et al., 2010; Osborne, Black, Wadsworth, & Meadows, 1994; Trundle et al., 2007). While children appear to understand that lunar phases occur in a regularly recurring sequence or pattern, most are unable to identify the observable scientific sequences (Hobson et al., 2010; Trundle et al., 2007). Some children believe the moon changes in size by getting larger and smaller in length and width as it changes in appearance during the cycle of moon phases (Roald & Mikalsen, 2001; Za'rour, 1976).

Children's explanations for the cause of moon phases generally change with their ages. Very young children often describe human actions and supernatural forces as being responsible for the lunar phases. With increased developmental age children begin to attribute causes of moon phases to natural phenomena such as the wind or clouds (Haupt, 1950; Piaget, 1972). During the early elementary grades, children begin to incorporate a blocking mechanism into their explanations for the cause of the lunar phases. Children begin to assert that objects, including the Earth or other planets, prevent sunlight from reaching the moon (Hobson et al., 2010). This causal mechanism appears to retain popularity even into adulthood (Trundle, Atwood, & Christopher, 2002).

Children's conceptual understandings of lunar concepts are likely to be influenced by their culture. For example, Doğru and Şeker (2012) found that Turkish children were more familiar with the crescent moon and propose this could possibly be due to the crescent moon being a cultural and a national symbol in Turkey. Za'rour's (1976) study with Lebanese children reported significantly more Christian children perceived the moon as changing in appearance than Muslim children.

Collectively, the findings of the studies on children's conceptions of the day and night cycle and lunar concepts suggest that children from different cultures begin to make observations of astronomical objects and events early in their everyday lives and construct predominantly similar naïve and synthetic mental models of space science phenomena. The current study included the concepts of identifying the time of day (day or night), providing evidence for the time of day, recognizing the colors of the day and night skies, identifying celestial objects that can be observed in the day and night skies, and recognizing the times of day when celestial objects are likely to be observed. This early observational and culturally based knowledge held by young children is likely to influence the construction of their mental models of the day and night cycle.

Methods

Participants

A total of 56 children, 27 US and 29 Turkish, participated in the study. US children were recruited from a publicly funded preschool where approximately 85% of the families received funding aid. The preschool was in a Midwestern metropolitan city in the USA.

Turkish children were recruited from a publicly funded preschool serving children of low-income families in a city located in the Northwestern part of Turkey. The children ranged in age from 48 to 60 months. Slightly more than half of the children were boys (17 US and 12 Turkish) and 44.8% of the children were girls (10 US and 17 Turkish). The teachers in the classrooms where the children were recruited reported that no instruction targeting the day and night cycle was implemented in their classrooms prior to data collection or analysis.

Data collection and analysis

Semi-structured interviews were conducted with each child individually to describe preschoolers' understandings of the day and night and objects in the sky. The interview protocol (Appendix 1) included a total of nine questions developed and based on US state standards and a Framework for K–12 Science Standards: Practices, Crosscutting Concepts, and Core Ideas (Schweingruber, Keller, & Quinn, 2012). Interviews were recorded digitally and then transcribed.

The constant comparative method was used to analyze the children's responses. The constant comparative method was designed for use in the grounded theory methodology by Glaser (1965) and Glaser and Strauss (1967). The main purpose of this method is to generate theory through 'joint coding and analysis' (Glaser, 1965, p. 437) and to compare responses from all children. In order to develop conceptual models and categories, this method of analysis continuously questions, compares, and delimits the data (Boeije, 2002; Glaser, 1965; Glaser & Strauss, 1967). This type of data analysis has been used in science education research focused on various concepts including moon phases (Trundle et al., 2007), the particulate nature of matter (Adadan, Trundle, & Irving, 2009), tides (Ucar & Trundle, 2011; Ucar, Trundle, & Krissek, 2011), and seasons (Wild & Trundle, 2010). In order to examine the construct validity of the interview protocol including nine questions Rasch analysis was used. Initially, children's responses were coded and then scored based on their alignment with a scientific explanation. Responses to each interview item were scored either 1 or 0. These scores were used in the Rasch analysis, which was performed using the Winsteps software (Linacre, 2009). Through Rasch analysis we examined how well the interview questions defined the latent trait, observational knowledge of astronomy, and the difficulty level of the interview questions. Rasch analysis was also used to convert children's raw scores to linear units ranging from 0 to 100, which are more suitable for parametric statistics such as ANOVA. While the difficulty levels of interview questions were calculated to make a fine-grained comparison of US and Turkish children's performances on each interview question, the outcome measures were calculated to make a general comparison using a two-way ANOVA test.

Results

Responses to interview questions

Results demonstrated that almost three-fourths of the US children (20 out of 27) were able to accurately identify the outside sky as a day sky. Eleven of these children (41%) were able to provide evidence to explain how they knew it was day. For example, many students noted 'the sun's out' or 'there is light in the sky and the sky is light blue'. Only one-third of the children (33%) were able to describe typical celestial objects associated with the day sky. Slightly more than half of the children were able to describe the observable objects in the night sky (56%). The children's responses for objects observable in the night sky considered as scientific were the stars and moon. While half of the children were able to speak to this, many other responses included distractors such as clouds, birds, and airplanes. The least known time when a celestial object could possibly be observed was that of the moon (44%), many stating that the moon was only observable at night, not both day and night. Slightly more than 70% of the children were able to explain that the sun can only be visible during daytime and 63% were able to explain that the stars are visible during nighttime.

A majority of Turkish children (25 of 29, or 86%) were able to identify the outside sky as a day sky. Twelve of these children (41%) were able to provide evidence to explain how they knew it was day. Similar to US children, few Turkish children were able to describe typical celestial objects associated with the day sky (41%). However, almost three-fourths of Turkish children were able to describe the observable objects in the night sky (72%). The least known time when a celestial object could possibly be observed was that of the moon (17%). Almost 59% of the children were able to explain that the sun can only be visible during daytime and about 62% were able to explain that the stars are visible during nighttime. Figure 1 presents children's scientific responses to interview questions.

Interview question difficulty

Rasch analysis was performed to calculate the difficulty measures of interview questions. A Wright map was constructed to examine the difficulty level of interview questions (see Figure 2). Children's performance (right part of the figure) and difficulty level of interview questions (left part of the figure) were displayed on the Wright map. Interview questions were presented in increasing difficulty along a line representing the construct (children's knowledge of objects in the sky) defined by the interview questions. While the interview questions at the top of the map were the hardest questions for the children, questions at

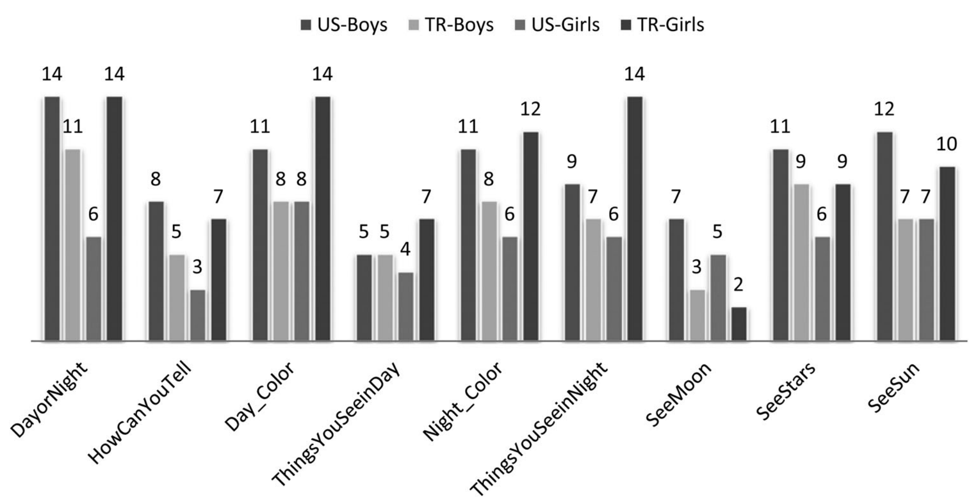

Figure 1. Scientific responses by nation and gender

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                 INTERVIEW QUESTIONS - MAP - U.S. & TURKISH CHILDREN
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    2                              +
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                                   |
                                   |
SEEMOON (1.49)                     | TB  TB  UB  UB  UB  UB  UB  TG  TG  TG  TG  UG
                                   |
                                   |
                                   |
YOUSEEDAY (1.09)                   |
    1                              +
HOWCANYOUTELL (0.90)               |
                                   |  TB  UB  UB  UB  TG  TG  TG  TG  UG  UG  UG  UG
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                                   |  TB  TB  UB  UB  TG  TG  TG  TG  TG  UG  UG
                                   |
    0                             M+
                                   |
SEESTARS (-0.21)                   |
SEESUN (-0.31)  YOUSEENIGHT (-0.31) |  TB  TB  TB  TG  UG  UG
NIGHT_COLOR (-0.42)                |
                                   |
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                                   |  TB  UB  TG  TG
DAY_COLOR (-0.85)                  |
   -1                              +
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DAYORNIGHT (-1.37)                 |
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Note: Item measures are in parenthesis. UB=U.S. boys, UG=U.S. girls, TB=TR boys, TG=TR
girls.
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Figure 2. Wright map

the bottom of the map were the easiest questions for the participants in this study. For example, the most difficult interview question for the children was the question about the time of observation for the moon and the easiest interview question was the question that required children to identify the outside sky as daytime or nighttime. Children's performances are presented on the right part of the figure using two letters (first letter representing nation and the second letter representing gender) in increasing competency. While the children with the highest competency are located at the top of the map, children with the lowest competency are located at the bottom of the map. For example, the most competent child was a US boy with a logit score of approximately 3.0, and his score is located at the top right part of the map. This child was expected to answer all interview questions accurately.

Results of differential item functioning (DIF) analysis indicated that the interview question about the time of observation for the moon did not have the same difficulty level for Turkish and US children (DIF contrast: 1.55). This question was easier for US children (DIF = 0.75) to respond to when compared to Turkish children (DIF = 2.30). The difference between these two difficulty measures was statistically significant ($\chi^2 = 5.28$, df = 1, $p = .022$). In other words, US children were more likely to perform better than the Turkish children on this particular question. DIF analysis did not reach significance for the remaining interview questions.

Comparison of US and Turkish children's performances

Children's responses to interview questions were analyzed to calculate person outcome measures (Wright & Stone, 1979). The outcome measures were rescaled to user-friendly linear logit scores ranging from 0 to 100. These scores were used in the two-way ANOVA test to compare children's performance (see Table 1 for the mean and standard deviation of logit scores for the children). The ANOVA results indicated that there was no statistically significant difference between US and Turkish children ($F(1, 52) = 0.06$, $p > .05$) or between boys and girls ($F(1, 52) = 0.64$, $p > .05$). Nation by gender interaction also was not statistically significant ($F(1, 52) = 0.01$, $p > .05$). These results suggest that overall performances of US and Turkish children and boys and girls were comparable.

Discussion

Framework theory suggests that entrenched presuppositions about natural phenomena acquired early in life influence children's construction of specific theories which includes interrelated propositions about natural phenomena. These specific theories in turn support the generation of mental models of science phenomena (Vosniadou, 1994; Vosniadou et al., 2008). Framework theory also suggests that domain-specific presuppositions

Table 1. Descriptive statistics for logit measures

Nation	Gender	Mean	SD	*N*
Turkey	Boys	56.24	16.53	12
	Girls	55.14	11.76	17
	Total	55.60	13.66	29
USA	Boys	55.20	23.53	17
	Girls	53.93	11.12	10
	Total	54.73	19.59	27
Total	Boys	55.63	20.59	29
	Girls	54.69	11.33	27
	Total	55.18	16.63	56

that influence children's observations might be universal and children typically share similar observational experiences (Vosniadou, 1994). Therefore, children in different cultures should share similar observational knowledge of the day and night cycle (Vosniadou & Brewer, 1994). The current study aimed to examine US and Turkish children's observational knowledge of astronomy. The results demonstrated that the observational knowledge of preschoolers from two cultures have great similarities as predicted by the framework theory (Vosniadou & Brewer, 1992; Vosniadou et al., 2008).

Findings of the present study suggest that US and Turkish preschoolers are able to make informal observations of the sky, and the overall performances of the children were comparable with one expection. US children were more likely to perform better than the Turkish children on the question about the time of observation for the moon. This concept is typically targeted in US preschool and kindergarten programs. It appears that the only impact the program differences had on children's performances is the knowledge of time of observation for the moon. The Turkish early childhood education program is a developmental program based on the 'whole child' philosophy. The Turkish program aims to support the development of children's socio-emotional, cognitive, motor, language, and self-care skills (MEB, 2012). Unlike the US program, the Turkish early childhood education program does not include early learning content standards for science and only makes references to the acquisition of some science process skills like making observations and establishing a cause and effect relationship. In contrast, early learning content standards of many states in the USA, such as Ohio, make explicit references to basic science concepts in various domains including space science (Saçkes et al., 2010). Although science concepts and skills are better represented in US early childhood education programs than the Turkish program, as predicted, this advantage did not translate into overall performance differences between US and Turkish children possibly due to low implementation fidelity (Maier, Greenfield, & Bulotsky-Shearer, 2013; Saçkes et al., 2011).

Nevertheless, superior performances of US children on the item that targets their knowledge of time of observation for the moon might be a facilitating factor in the development of their causal explanation for the day and night cycle in the long run. Very young children tend to believe that the sun is in the sky during the daytime, while the moon and stars are in the sky during the nighttime, but not daytime. These limited observations of young children appear to promote the idea that the appearance of the sun and the disappearance of the moon and the stars in sequence causes the day and night cycle (Vosniadou & Brewer, 1994). Along with exposure to scientific knowledge of rotation and orbit, this idea possibly leads children to construct several misconceptions or synthetic models, such as a Rotation + Distance model where the Earth's rotation on its axis as the sun moves far away and comes back produces the day and night cycle (Saçkes, 2015b; Vosniadou & Brewer, 1994). Research studies suggest that knowledge of basic science concepts, such as shape of the Earth, promotes children's scientific understanding of the cause of the day and night cycle (Vosniadou, 1991). The knowledge that the moon can be observed both in the day and nighttime might be basic knowledge that facilitates construction of scientific understanding of the cause of the day and night cycle. In other words, children with observational knowledge that the moon can be observed both in the day and nighttime might be more likely to develop a scientific understanding of the cause of the day and night cycle.

The findings of the present study should be considered as preliminary support for the predictions of framework theory regarding the universality of children's domain-specific presuppositions of astronomy and children's observational knowledge that are constrained by them. The present study did not directly investigate the presuppositions, but rather focused on children's observational knowledge. However, we believe that making inferences about presuppositions based on observational knowledge is warranted for the following reason. Framework theory suggests that presuppositions influence children's interpretations of their everyday observations of natural phenomena. In other words, observational knowledge, as presented by children in their utterances, are indicators of their presuppositions. Presuppositions can be perceived as latent constructs that are not directly observable but can be inferable from children's utterances that represent their observational knowledge.

The findings also highlight the limitations of the implementation of the US early childhood education program. Nevertheless, these findings should be interpreted with caution as the sample size from the countries was small and limited to two study sites. Further studies should investigate whether instructional practices in early childhood classrooms are aligned with and effective in meeting the targets of the program. The findings of the present study suggest that the concept of a spherical Earth and rich observational experiences that focus children's attention on the time of observation for moon should be introduced before the implementation of science instruction on the cause of the day and night cycle. Developmentally appropriate instructional interventions that provide carefully planned opportunities for sky observations and invite children to reflect on their observations might capitalize on children's documented capabilities in making sky observations in the current study. Consequently, this type of intervention might also help preschoolers develop scientific mental models of the day and night cycle and other science phenomena targeted in the programs. Future studies should also examine the effectiveness of such interventions on preschoolers' conceptual understandings of the standard-based space science concepts and the day and night cycle.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Appendix 1. Interview Protocol for Children (Objects in the Sky)

Comparing Day and Night

- Look at the sky from the window right now and tell me, do you see a day sky or a night sky?
- How can you tell it is day (or night)?
- What color is the sky now?
- What things can you see in the day sky?
- What color is the night sky?
- What things can you see in the night sky?

Observation Time

- When can you see the moon?
  - Can you see the moon during the daytime/at nighttime?
- When can you see the stars?
  - Can you see the stars at daytime/nighttime?
- When can you see the sun?
  - Can you see the sun at daytime/nighttime?