EXPLORING THE RELATION BETWEEN GESTURE PRESENTATION PERSPECTIVE AND CHILDREN'S SPATIAL PERFORMANCE

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ABSTRACT

EXPLORING THE RELATION BETWEEN GESTURE PRESENTATION PERSPECTIVE AND CHILDREN'S SPATIAL PERFORMANCE

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The presence of gestures with visuospatial materials enhances the children's spatial performance. Although it is an emergent context in online educational tools, no study so far investigated whether and how the perspective of a speaker's gesture presented to children relates to differences in spatial performance. Whether the perspective of multimodal input relates differently to 5-year-old children's spatial performance by varying the perspective of gesture presentation in virtual visuospatial maps investigated in this study. 5-year-old monolingual Turkish children were engaged in the Directions Task. The task included visuospatial maps and videos of speakers describing routes in the map by three conditions: Speech-Gesture combination with a front-facing view, Speech-Gesture combination with an upper back angle, and Speech-only conditions with a front-facing view for control. Children were asked to verbally recall and then draw the route described to them in the videos after each trial. Children's verbal responses were coded for the correct recall of target information in the route descriptions for spatial (e.g., behind) and location (e.g., house) information. They also engaged in perspective-taking (Frick et al., 2014), mental rotation (Frick et al., 2013), and relational thinking (Christie & Gentner,

2013) tasks. Linear mixed effect modeling regression analysis showed that children's verbal recall, but not necessarily behavioral recall, enhanced in multimodal directions. Moreover, children's relational reasoning and perspective-taking abilities modulate children's verbal recall performances. The results of this study underline the importance of multimodal input and presentation perspective in enhancing children's spatial performance.

Keywords: Perspective, Visuo-Spatial Maps, Gesture Presentation, Spatial Performance

ÖZ

JEST GÖSTERİM PERSPEKTİFİYLE ÇOCUKLARIN UZAMSAL BECERİLERİ ARASINDAKİ ETKİLEŞİMİN İNCELENMESİ

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Görsel-uzamsal materyallerle birlikte sunulan jestler, çocukların uzamsal performanslarını arttırmaktadır. Günümüzde çevrimiçi eğitim materyallerinde yer almasına rağmen, konuşmacının jestlerinin perspektifinin çocukların uzamsal becerilerinde nasıl bir etkiye sahip olabileceği araştırılmamıştır. Bu çalışmada, multimodal dil girdisinin perspektifinin, okul öncesi çocukların uzamsal becerileriyle ilişkili olup olmadığı araştırılmıştır. Bu sebeple ekran üzerinden görsel uzamsal haritalar gösterilirken, jestler farklı perspektiflerde sunulmuştur. 5-6 yaş aralığında, anadili Türkçe olan çocuklar Harita Görevine katılmışlardır. Bu görev, görsel-uzamsal haritalarla birlikte, üç koşulda yol tarifinde bulunan konuşmacı videolarını içermektedir: Ön-yüz görünümünden konuşma ve jest kombinasyonu, üst-arka açıdan konuşma ve jest kombinasyonu, ön-yüz görünümünden sadece konuşma koşulu. Çocuklardan, her videodan sonra konuşmacının anlattığı yolu sözlü olarak tekrar etmeleri ve yolu çizmeleri beklenmiştir. Çocukların sözel ifadeleri yol tarifinde uzamsal, mekânsal ve eylem bildiren hedef kelimeler ele alınarak kodlanmıştır. Çocuklar aynı zamanda perspektif alma, zihinsel döndürme ve ilişkisel akıl yürütme görevlerine dahil olmuştur. Linear mixed model regresyon analizi kullanılarak analiz edilen sonuçlara göre, çocuklara sunulan görsel-uzamsal haritalarda multimodal dil girdisi kullanmak, çocukların yalnızca sözel yanıtlarını

olumlu yönde etkilemiştir. Multimodal dil girdisinin olumlu etkisi çocukların davranışsal yanıtlarında gözlemlenmemiştir. Ayrıca, çocukların ilişkisel akıl yürütme ve perspektif alma becerilerinin sözel hatırlama performanslarını etkilediği görülmüştür. Çalışmanın sonuçları multimodal dil girdisi ve multimodal dilin perspektifinin çocukların uzamsal becerilerine olan etkisinin önemini vurgulamaktadır.
Anahtar Kelimeler: Perspektif, Görsel Uzamsal Haritalar, Multimodal Dil Girdisi, Uzamsal Beceriler

To my dearest father,

Metin Orakçı

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CHAPTER 1

INTRODUCTION

The traditional education system had to undergo a radical change to adapt online education during COVID-19 (Umeta et al., 2022; Tadesse & Muluyye, 2020). Teaching online limits human interaction, and the groups most affected by online education have been children (Parlakkilic, 2021). While providing information online, external factors, including the speaker's language and gestures, and internal factors, such as perspective-taking, mental rotation, and relational reasoning abilities, can directly affect the audience's comprehension. For some domains, such as space, the audience's benefit from these factors may have the upmost importance. Previous work has indicated a significant effect of using spatial language, including visuospatial directive information like landmarks and actions, along with the speaker's gesture use on the children's comprehension of spatial information (Austin & Sweller, 2014). However, the results would not be generalizable to online contexts. Although it is an emergent context in online educational tools, no study has investigated whether and how the interplay between the perspective of a speaker's gesture presented to children as well as children's spatial abilities relates to differences in spatial performance. Here, we investigated whether the 5-year-old children's spatial abilities and perspective of multimodal input relate differently to their spatial performance by varying the perspective of gesture presentation in virtual visuospatial maps. To do that, children were given route descriptions in different modalities and perspectives and were later asked to tell the route by themselves and show it on the map.

1.1. Spatial Understanding & Navigation

Spatial understanding is a cognitive ability that includes space, movement, shapes, directions, and position (e.g., Hund et al., 2021; Uhlenberg & Geiken, 2021; Young et

al., 2018). It helps to explore the world and create an awareness of the environment. To sustain independence, its development rapidly continues to improve throughout the preschool years.

In early childhood, spatial understanding develops with spatial language (Clingan-Siverly et al., 2021; Gentner et al., 2013; Hund et al., 2021). Using spatial language enhances preschool children's task performance in spatial relational mapping (Loewenstein & Gentner, 2005), and spatial vocabulary estimates current and further spatial reasoning abilities (Simms & Gentner, 2019).

Current literature argues that the effect of spatial language could not be limited to speech since non-verbal language elements like gestures also improve spatial understanding. Those investigating the relationship between gesture use and spatial understanding with adult samples illustrate that gesture use during speech is more efficient for processing spatial information, and gesture use directly affects adults' comprehension when speech content includes spatial input (Brooks et al., 2018; Driskell & Radtke, 2003; Göksun et al., 2013; So et al., 2015). In spatial descriptions, gesture use also affects children's spatial understanding and navigation abilities, vital for safety and independence throughout life (Gazova et al., 2013). Few studies focused on children considering the issue. While investigating the relationship between gestures and spatial reasoning, children's use of gestures predicted their performance on spatial analogies (Miller et al., 2020). Gesture use also enhanced children's verbal recall and route navigation performances in a study investigating preschool children on a zoo-themed visuospatial array (Austin & Sweller, 2017). Studies comparing children and adult samples demonstrated that children use fewer gestures than adults while describing a route; however, they use more iconic gestures than adults (Austin & Sweller, 2018). Children benefit more from gestures than adults when the spatial directions described to them include gestures on visuospatial maps (Austin & Sweller, 2014). Their recall of location and movement information was better when directions included gestures. Moreover, Kartalkanat and Göksun (2020) also investigated children's and adults' recall performances across route description stories presented with no gestures, beat, or iconic gestures. Participants' recall of location, objects, events, and directions was considered, and it was illustrated that both children and

adults performed better when descriptions were presented with iconic gestures compared to beat and no gesture presentation. This previous literature clearly demonstrates that the spatial language and gesture use relate to the spatial understanding of adults and children with greater emphasis.

In the digital age, spatial understanding and navigation studies have also considerably included virtual environments since researching physical environments requires higher material and physical resources (Qiu et al., 2020). The research investigated spatial abilities in virtual environments, including various age groups (Gyselinck et al., 2013; Nys et al., 2018), visual dimensions (Sampaio et al., 2017; Weisberg et al., 2014), human interactions (Pouliquen-Lardy et al., 2015), and learning methodologies. Qiu et al. (2020) explored the issue with college students using virtual, physical, active, and passive learning methods. While emphasizing 2D map-assisted field navigation learning's superiority over virtual counterparts, they also suggested that virtual learning is equally efficient to physical learning while acquiring spatial concepts like analogous landmarks. They also underlined that participants' performances between active and passive learning do not differentiate significantly when utilizing street view maps, and compared to active learning, passive learning can easily aid the process of spatial acquisition when quality learning resources are available. However, these results must be more generalizable considering children's spatial abilities and variations in language and gesture use combinations presented to them.

Since the literature presents the considerable effect of gestures on spatial understanding and recognition of spatial, location, and action information, it was aimed to manipulate a speaker’s gesture use and perspective while investigating speakers' descriptions' effect on children's ability to comprehend spatial navigations presented on screen based on their verbal and behavioral recall performances. However, it is firstly essential to demonstrate the internal and external mechanisms of gesture comprehension and investigate how the change in perspective can affect it.

1.2. Gesture Comprehension

Gestures are one of the main components of language in human interaction, which enhances the comprehension of visible speech (Drijvers & Özyürek, 2017). Their

production and comprehension are shaped by external sources like communication context, qualities of the tasks, and internal sources like age, personality, cognitive and perceptual abilities (Özer & Göksun, 2020).

Considering content-based and contextual external factors, gesture comprehension and production are affected by the characteristics of the speaker and the audience. The speakers adapt their message to the audience's age and knowledge (e.g., Campisi & Özyürek, 2013; Clark & Estigarribia, 2011). Adults use more consistent gestures when introducing novel things to younger children to keep their attention (Clark & Estigarribia, 2011). They use more details in their speech with richer iconic gestures when communicating to an imaginary child than when they imagine themselves communicating the same message to an adult (Campisi & Özyürek, 2013). Adults are also sensitive to the audience's background knowledge and use more representational gestures when content is unfamiliar to the audience than older adults (Schubotz et al., 2015). While current literature demonstrates the importance of speakers' using multimodal language for audiences, especially children, to what extent children benefit from the modality has not been investigated in detail.

Studies that include gestures also present how recipients comprehend gestures. Holler et al. (2014) manipulated the speaker's eye gaze in her message by combining speech and hand gestures. While the speaker's gaze is averted and the speaker uses her speech only but does not use gestures, the adult audience struggles to comprehend. However, the audience's comprehension enhances when the speaker uses speech and gesture together, even though her gaze is averted. Manipulations regarding the visibility of the speaker's mouth, the clarity of her voice, and gesture use in the speaker's messages demonstrated that younger and older adults benefit from gestures and visible speech when the speaker's voice is disrupted; moreover, the clarity of voice predicts the audience's performance when the speaker's speech is not visible and does not use gestures (Schubotz et al., 2020).

Focusing on internal sources, one's cognitive abilities, such as perspective-taking, mental rotation, and relational reasoning abilities, affect gesture use and comprehension. The ability to consider different viewpoints, which is crucial for social

interaction and communication: perspective-taking ability (Frick et al., 2014) is an essential internal source for gesture comprehension and emergent focus of educational studies related to children (Yadollahi et al., 2020). Gesture studies on perspective included first-person, second-person, and third-person views (Zhang et al., 2018). Gesture use and the speaker's perspective relate to external sources like social interactions, especially the feeling of being addressed, and gestures from an egocentric perspective can even enhance the neural processing in social interactions (Nagels et al., 2015). Gesture presentation perspective also affects task performance which is when perspective aligns with the speaker's perspective, task comprehension becomes more complex than seeing gestures from the listeners' own perspective (Hostetter et al., 2018). On the other hand, when the presentation of co-speech gestures' perspective was manipulated considering the character and observer viewpoints in narration (Hinterwimmer et al., 2021), not a specific viewpoint of gestures but informativeness was found to be more important for adults.

Mental rotation is one of the critical aspects of spatial cognition that involves the cognitive process of mentally rotating objects (Frick et al., 2013). Accumulated evidence so far from the literature focusing on its interaction with gestures revealed that gesture use during mental rotation tasks enhances the problem-solving abilities of adults (Çapan et al., 2024; Chu & Kita, 2011) and children (Goldin-Meadow et al., 2012; Levine et al., 2018). When adults were encouraged to use gestures, their performance on mental rotation tasks was enhanced compared to when they were not encouraged (Chu & Kita, 2011). Moreover, children's use of relational and analogical gestures in spatial analogies is also related to their mental rotation abilities (Miller et al., 2020) when their speech and gesture use is observed during the spatial analogies and mental rotation tasks.

Another critical internal source related to gesture comprehension is relational reasoning ability, which is essential in daily and scientific reasoning abilities and shapes humans' mental capacities while differentiating human mental capacities from other species (Christie & Gentner, 2014; Kroupin & Carey, 2021). While relational reasoning ability affects the quantity, form, and interconnectedness of gesture use (Cooperrider et al., 2016), gesture use in descriptions enhances children's analogical

reasoning and problem-solving abilities by making complicated items more explicit for them (Guarino & Wakefield, 2020).

The comprehension of gestures has been studied involving virtual environments (Godwin-Jones, 2023), human-computer interaction (Papanagiotou et al., 2021), VR devices (Zhang et al., 2018), and wearable cameras (Bandini & Zariffa, 2023; Garcia del Molino et al., 2016) currently. Those studies focusing on gesture view in virtual environments underline its interaction with spatial performance and the importance of emergent presentations in online educational tools directed to children. However, these should be more inclusive for children and focus on the relation between spatial performance and modality of language.

1.3. The Present Study

Literature demonstrated a considerable relationship between spatial understanding and gesture comprehension affected by internal and external sources. Here in this study, we aimed to test the internal performances of children considering perspective-taking, mental rotation, and relational thinking abilities and experimentally vary external factors with presentation perspective and gesture use of the speaker (speech-only from a front-facing view, speech-gesture combination from a front-facing view, and the combination of speech-gesture from an upper-back angle). Although the literature demonstrates evidence that internal and external sources affect gesture use and comprehension, a broader exploration of the interaction between internal and external sources of gestures is needed. On the other hand, the relation between spatial performance and perspective of gesture presentation, considering an upper-back angle, has not been investigated before, although it is an emergent context in online educational tools directed to children, such as drawing, tool making, etc. Lastly, how different gestures and speech use of the speaker would affect children's spatial performance, considering verbal recall and drawing have not been evaluated with virtual visuospatial maps. Thus, this study investigated how internal and external sources affect children's performance on visuospatial maps by varying speaker presentation conditions and gesture use.

To test this, we presented children visual-spatial maps and route descriptions in varying perspectives and multimodality. Children have been asked to describe the route to assess verbal recall and draw the correct path on the map to measure direction-following behavior. Children's verbal recall elaborated considering the information recalled: spatial, location, and action following the previous work (Austin & Sweller, 2014; Kartalkanat & Göksun, 2020). Children's general cognitive and spatial abilities (perspective taking, mental rotation, and relational reasoning) have also been assessed to examine their effect on their performances on the visual-spatial maps.

1.4. Predictions

Considering the current literature on gesture use enhancing children's spatial understanding (Austin & Sweller, 2014; Austin & Sweller, 2017, 2018; Miller et al., 2020), we predicted that children would have significantly better verbal recall performance when they receive directions when speech and gestures present than speech-only directions. Specifically, Austin and Sweller (2014) showed that children recall more location words and movement when presented with speech and gestures than when using only speech. Considering this result, children's drawing behavior and verbal location recall performance were expected to be better in the speech-gesture front-facing condition than in the speech-only front-facing condition. However, we did not have any predictions as to whether and how providing speech and gestures from the upper-back condition results in differences between the other conditions. Moreover, we explore whether this interaction may vary across the verbal spatial and action recall.

We also expected children's spatial performances to interact with gesture use and presentation perspective, resulting in differences in their recall performance. Firstly, since seeing gestures aligning with a listener's perspective can enhance task performance (Hostetter et al., 2018; Nagels et al., 2015), we expected a significant interaction between children's perspective-taking abilities and their verbal recall performance in the speech-gesture upper-back condition compared to the speech-gesture front-facing condition. Moreover, we explore whether this interaction may vary across the types of recall (spatial, location, and action).

Previous literature indicated conflicting results regarding children's gesture production and comprehension concerning mental rotation abilities. While Miller et al. (2020) suggested that children's use of movement gestures does not predict their mental rotation abilities, other studies show a considerable interaction between mental rotation skills and children's comprehension of gestures involving movement or action, which enhances children's spatial learning (Levine et al., 2018; Goldin-Meadow et al., 2012). Since we focused on children's comprehension, we expected a significant association between mental rotation and verbal action recall performance of children when they received directions in conditions that included gestures. Nevertheless, we do not have any predictions concerning the interaction between mental rotation abilities and children's verbal spatial and location recall.

Moreover, with respect to relational reasoning, prior evidence from the literature underlines the association between gesture use and relational reasoning (Guarino & Wakefield, 2020). Thus, we predicted a significant positive interaction between children's relational reasoning and verbal recall performance in the speech gesture combination conditions. Moreover, we explore whether this interaction may vary across the types of recall (spatial, location, and action).

Lastly, it is possible that children's perspective-taking, mental rotation, and relational reasoning abilities could interact with each other, also considering their visuospatial performance and the speaker's use of speech and gesture variations.

CHAPTER 2

METHOD

Ethical approval of the study was obtained from the Middle East Technical University Human Research Ethics Committee (numbered 308-ODTUİAEK-2023). Moreover, research consent from the Ministry of Education (numbered 54850036-605.01-E.527) was obtained to administer this study in the school setting.

2.1. Participants

Fifty-two (29 girls, Mage = 69 months, SD = 9.2 months, Age Range = 4.5 – 6 years) monolingual-Turkish-speaking children residing in Turkey participated in the study. Children who have disabilities and language delays and are using psychiatric medications, based on parental reports, did not participate in the study. Participants' demographic information was gathered from their parents via online or printed-out forms. The results of the demographic form showed that 78.85% of the mothers have a bachelor's degree or higher level of education (e.g., Master's or PhD degrees), 11.54% of mothers have a high school degree, and 15.38% have less than a high school degree. Three mothers did not answer the question regarding education. Household income was also obtained from the parents, with 36% of parents identifying as high-income, 42% as middle-income, and 26% as low-income. Children's daily use of technological devices (e.g., tablets, telephones, or computers) is also obtained, and 98% of the children are reported to use either one of the devices daily.

2.2. Measurements

2.2.1. Directions Task

The Directions task was developed to gauge the visuospatial performances of children. The Directions Task was presented to children on a tablet screen. The main layout had

a map in the screen's bottom left corner and a video of a speaker in the upper right corner (see Figure 1 for the layout).



Figure 1. *Example of the speaker's description conditions: Speech-Only Front-Facing, Speech-Gesture Front-Facing, and Speech-Gesture Upper-Back*

Maps were designed on a 2x3 array, including landmarks and roads, using Canva Pro, a graphic design tool. The background was light green, and the road colors were light gray to highlight landmarks. Roads were positioned as one with horizontal position in the middle of the map and vertical roads between the landmarks. Moreover, small roads were placed to link the landmarks to the roads. Landmarks included house, school, park, slides, swing, pool, apple tree, rocks, cat, market, table, balloon seller, ice-cream truck, ferris wheel, flowers, and bench. There were also human characters who did not move throughout the task (only popped up to imply their initial location), and each trial map included its own human character with varied locations. Landmarks and the positions of the roads were adjusted based on the pilot study (N = 3, Mage = 58 months, SD = 18.5).

There was a total of three maps. Each map was presented three times under different description conditions: Speech-only description with a front-facing view, speech-gesture combination with a front-facing view, and speech-gesture combination with an upper-back angle. Thus, in total, nine trials with different route descriptions were included. Trials had 14.4 seconds average (SD = 1.25) video duration.

In all description videos, the speaker's face was invisible since we wanted to observe the effect of perspective change by focusing on the hands. Description videos were recorded by researchers. In the videos, the actor sat behind a white table with a black shirt to make the gestures more vivid. She described the route descriptions in a neutral tone. While using gestures, the actor used target words aligning with gestures. In the

videos, gestures provided information about locations, spatial information, and actions. Route descriptions included 1 character and 3 landmarks; one was the character's starting position, on-road stop, and final destination. Each route description included 2 or 3 target spatial words (M = 2.78, SD = 0.52), 3 target location words (M = 3, SD = 0), and 2 to 4 action words (M = 3.11, SD = 0.51). See Appendix B for all route descriptions used in the study.

Before the experiment, we piloted to see if any route descriptions were more appealing. To do so, we presented each description to 18 adults and asked them to rate their appeal on a 5-point Likert scale (1 = not attractive, 5 = very attractive). They were asked to evaluate the appeal of route descriptions individually, considering 5-year-old children's points of view. Results showed that none of the maps has an appeal score of 2 SD above or below the mean (M = 3.18, SD = 0.479).

Children were shown all trials (N = 9) in a randomized order. After each trial, participants were asked to describe the route verbally and then draw it on a printed-out version of the map with a marker. Before administering the task, we completed a familiarization step to ensure the children understood and named all the landmarks on the maps. See Figure 1 for examples of conditions of the speaker's description.

2.2.2. PTT-C (Perspective Taking Test for Children)

PTT-C was used to assess children's perspective-taking abilities, developed by Frick et al. (2014). All objects were prepared by the researcher using the instructions of the task (Frick & Pichelmann, 2023). For the practice session of the task, children sat on a table behind the researcher. On the layout, which was positioned on the table, children saw two Lego human figures and two geometric, three-dimensional objects manufactured with paper. One of the figures was positioned at 90 degrees, and the other had a 180-degree angular difference from the child. Both figures were presented to children with distinct names (Ali, Eda, and Mert (not the leading figure but used as an object)), and both were holding cameras (See Figure 5.a for instruction layout). The instruction session described to the children: "Here are Ali, Eda, and their little brother Mert. One day, they went on a museum trip and took pictures of what they saw. Now I am showing you a photograph. Who took this picture, Ali, Eda, or anyone else?"

Children were shown four photographs of objects in different positions and were expected to answer the question after each photograph. Then, they were encouraged to walk behind the table and look at the objects from the perspective of figures to check out their answers. Children had to return and evaluate their answers. This session was conducted to help children experience perspective change.

After this instruction session, children were presented with printed photographs showing different perspectives (N = 27) in a file. The folder file was presented in a horizontal position. The first five pages represented a transition between Lego figures and the folder file (See Figure 2.b for an example item).

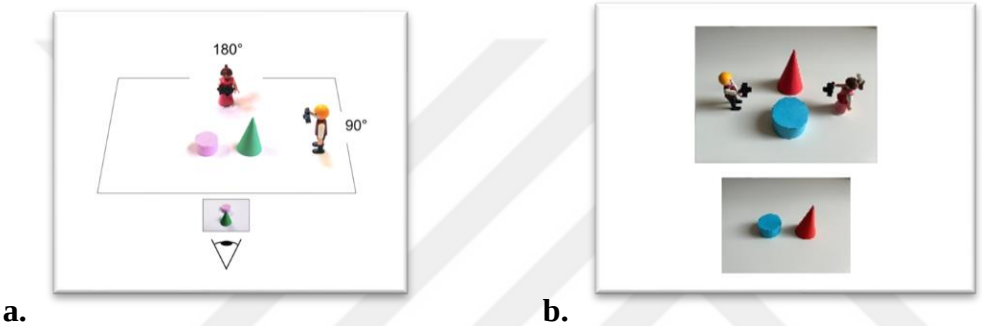


Figure 2. *Examples of trial sessions in PTT-C.*

Test objects were presented in a horizontal position, one descriptive photograph with a figure and objects representing a photograph-taking position, and four possible choices were placed at the bottom part of this photograph. Photographs of possible choices were positioned in a randomized order on each page. Half of the test objects' choices covered the photographs from the children's perspective, yet the second half did not include an egocentric view. There was one figure in each test object. The presentation design includes combinations of different numbers of objects (1 to 3) and varied perspectives positions (0 angle, 90 angle, and 180 angle position). Test objects were presented to children in a folder file. They were asked, "Which photograph do you think Ali/Eda took?" and expected to show the photograph they chose. See Figure 3 for examples of test objects.



a. two objects with 0 angle **b.** 3 objects with 90 angle **c.** 1 object with 180 degrees angle

Figure 3. *Example test objects of PTT-C representing different object positions considering the angle.*

2.2.3. The Ghost Task

The Ghost Task was used (Frick, 2019; Frick et al., 2013; Frick & Pichelmann, 2023) to assess children's mental transformation abilities. The task was presented on letter-size paper with a horizontal position, including six instruction trials and twenty-one test ones. The task layout represents one main object at the top of the paper. Two objects were presented in black circles on the bottom of the paper; one was the rotated version of the main one. The shapes of keys, socks, hammers, sails, and ice skates were presented in the practice trials. The top object was matched with one of the bottom ones and printed on transparent paper. In the practice trials, children were asked which shape matches the main one. After their answer, they were encouraged to rotate the transparent object to find its target rotated version (See Figure 4 for an example of a test trial).



Figure 4. *Example trial of the Ghost Task.*

In test trials, ghost figures were included as objects. Children were asked, "Which one do you think matches with the target object?" in test trials (N = 21)

2.2.4. RMTS (Relational Match to Sample)

RMTS has been used to assess children's relational reasoning abilities (Christie & Gentner, 2014). On the tablet screen, children have seen eight sets of pictures, including pairs of geometric shapes. In the pictures, geometric shapes were on a white background and framed with black lines to create card-looking pictures. Each set consisted of three pairs of cards; the first pair would be a standard card, including two identical geometric shapes. After that, alternative pairs were presented. One of the following alternative pairs was a relational match, and the other was a non-relational match. Children were asked to show which pairs were more related to the standard pair. See Figure 5 for a sample display of the task.

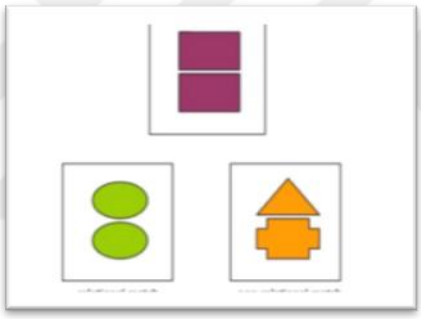


Figure 5. *Example sample display of RMTS.*

2.3. Procedure

The study was conducted in preschools and children's homes. For school assessments, the school administrators contacted the parents of children in the target age group and advertised the study. Printed informed consent and demographic forms were sent to parents via school administration before the study. For home visits, the study was announced on social media and parent support groups via fliers, including the study's aim. Interested parents reached out to the researcher, and they were informed about the procedure. An online informed consent form and a demographic questionnaire were distributed to them before the home visits.

Children were recruited individually, and the study was conducted in a quiet and suitable room in their kindergarten or house. Throughout the study, children sat in front of a table, and the researcher sat behind the child. After initial interaction with the child and warming up, the Directions Task, PTT-C, the Ghost Task, and RMTS were conducted in the same order for every child. The Directions Task and RMTS were conducted on the tablet, Ghost task, and PTT-C on the table with the researcher using folder booklets. For later coding of route descriptions and accuracy, the whole session was video recorded with an angle that records the child and the researcher during the tasks. The children were allowed to take breaks between tasks but not during the individual assessment of tasks. After completing all the tasks, the children were thanked for participating, and they received small gifts and a certificate of participation.

2.4. Coding

Turkish native speakers transcribed and coded the tasks based on the video recordings. The coding of the Directions task was administered based on the children's transcribed verbal responses and their drawings. Verbal responses were transcribed and coded word by word in three main categories: spatial, location, and action information. Target, non-target, and free-recall words were counted for each category type. Total points were formed for each map and each information category: spatial, location, and action. Total points for each category were calculated based on target word recall divided by the maximum number of target words. To illustrate, a route description that include “Eda evin önünde dururken bir kedi gördü. Evin karşısına geçerek gördüğü kediyi sevdi. Sonra evin ve kaydırağın önünden yürüyerek okula gitti. (Eng. Eda stood in front of the house and saw a cat. She crossed to the opposite side of the house and petted the cat she saw. Then, she walked in front of the house and slide and went to school.” have target spatial words as “önünde (in front of), karşısında (across), önünde (in front of),” location words as “ev (house), kedi (cat), okul (school),” and action words as “durmak (standing), sevmek (petting), yürümek (walking).” A child’s recall of this route was “Evin karşısında duruyomuş sonra bi kedi görmüş onu sevmeye gitmiş ordan da okula gitmiş (Eng. She was standing across the house, then she saw a cat and went to pet it after that she went to school”.) For this response, there was only

one target spatial word as "karşısında (across)," target location words as "ev (house), kedi (cat), okul (school),” and the target action words as “duruyormuş (was standing), sevmeye (to pet).” The words "görmüş (saw), gitmiş (went)," counted as non-targeted action words as they were not part of the target words. We calculated the total score for spatial, location and action recall by dividing the number of target words recalled by the child to the target words present in the original description. Based on the description in the above example, the child gets a score of 0,39 for spatial recall, 1 for location recall, and 0,69 for action recall. This coding and calculation were done for each child for 9 test objects.

Children's drawings on the Directions task were coded based on four assumptions: 1) Are all the landmarks correctly indicated? 2) Is the route correct? 3) Is the order of the route correct? 4) Are the indented roads indicated?". Questions were answered using a Likert-type scale of 0-2 (0 = not correct, 1 = partially correct, 2 = entirely correct). This coding was conducted for all maps, and total points were calculated for each map, considering the average scores on the four-question scale. See Figure 6 for a child's drawing response for Map 1. Here is the example drawing response's coding and calculation: Are all the landmarks correctly indicated = 1. Is the route correct = 1 Is the order of the route correct = 1 Are the indented roads indicated = 1. In short, the total point found for this child's Map-1 drawing response was 0.5.



Figure 6. Example of drawing response in the Directions Task

For the PTT-C, the Ghost Task, and RMTS, the correct answers were counted as 1, and the wrong answers were counted as 0. Total points were counted without including the trial objects' scores.

2.5. Results

2.5.1. Analysis Plan

This study explored the effect of internal (perspective taking, mental rotation, and relational reasoning) and external sources (gesture use and perspective) on children's spatial performance. We used R 4.3.3 (R Core Team, 2022) to analyze the data via linear mixed-effect modeling regression analysis with the lmer (version 1.1.35.1; Bates et al., 2014), plot_model (version 2.8.15; Lüdecke, 2020), and sim slopes (version 1.1.5; Preacher et al., 2006) function to interpret and plot interactions. We conducted 4 linear mixed-effect models to assess children's verbal spatial, location, action recall, and drawing performance.

For each model, description conditions of the Directions Task (speech-only front-facing, speech-gesture front-facing, and speech-gesture upper-back) and children's scores from PTT-C, Ghost Task, and RMTS were entered into the models as the fixed effects. Moreover, participants and trials were entered as random slopes to control the variability coming from testing different participants and using different maps. See Table 1 for the fixed effects.

Description conditions were coded with Helmert Contrasts. At the first level, we wanted to observe the effect of perspective change and compare multimodal conditions from front-facing and upper-back views. At the second level, we wanted to evaluate the effect of gestures and compare the aggregate score of multimodal conditions with the speech-only condition. Based on these explorations, in the first level, the speech-gesture front-facing condition was coded as +1/2, the speech-gesture upper-back condition as -1/2, and the speech-only front-facing condition coded as 0. In the second level, the speech-gesture front-facing condition is coded as -1/3, the speech-gesture upper-back condition is coded as -1/3, and the speech-only front-facing condition is coded as +2/3.

Table 1. *Fixed effect estimates from lmer models for verbal spatial, location, action recall, and drawing performance.*

Verbal Spatial Model

Fixed Effects	ß(SE)	t	p
(Intercept)	0.08	-0.51	0.611
Description Condition [Level 1: SGFF vs SGUB]	0.15	0.65	0.529
Description Condition [Level 2: (SGFF & SGUB) vs SOFF]	0.13	-2.41	**0.037**
PTTC	0.10	1.03	0.307
RMTS	0.07	1.45	0.150
Ghost Task	0.08	2.03	**0.047**
Description Condition [Level 1 x PTTC	0.14	2.04	**0.041**
Description Condition [Level 2: (SGFF & SGUB) vs SOFF] x PTTC	0.12	-0.08	0.934
Description Condition [Level 1: SGFF vs SGUB] x RMTS	0.10	-0.41	0.676
Description Condition [Level 2: (SGFF & SGUB) vs SOFF] x RMTS	0.09	-0.67	0.497
PTTC x RMTS	0.11	-0.81	0.416
Description Condition [Level 1: SGFF vs SGUB] x Ghost Task	0.11	0.23	0.810
Description Condition [Level 2: (SGFF & SGUB) vs SOFF]x Ghost Task	0.10	-1.25	0.211
PTTC x Ghost Task	0.04	0.51	0.608
RMTS x Ghost Task	0.10	1.47	0.147
Description Condition [Level 1: SGFF vs SGUB] x PTTC x RMTS	0.16	-1.47	0.140
Description Condition [Level 2: (SGFF & SGUB) vs SOFF] x PTTC x RMTS	0.14	0.06	0.950
Description Condition [Level 1: SGFF vs SGUB] x PTTC x Ghost Task	0.06	0.62	0.531
Description Condition [Level 2: (SGFF & SGUB) vs SOFF] x PTTC x Ghost Task	0.05	0.32	0.748
Description Condition [Level 1: SGFF vs SGUB] x RMTS x Ghost Task	0.14	0.14	0.886
Description Condition [Level 2: (SGFF & SGUB) vs SOFF] x RMTS x Ghost Task	0.12	-0.17	0.860
PTTC x RMTS x Ghost Task	0.05	-0.22	0.823
Description Condition [Level 1: SGFF vs SGUB] x PTTC x RMTS x Ghost Task	0.07	-1.12	0.263
Description Condition [Level 2: (SGFF & SGUB) vs SOFF]x PTTC x RMTS x Ghost Task	0.06	-0.66	0.505

Verbal Location Model

Fixed-Effects	ß(SE)	t	p
(Intercept)	0.12	0.02	0.980
Description Condition [Level 1: SGFF vs SGUB]	0.27	-0.99	0.343
Description Condition [Level 2: (SGFF & SGUB) vs SOFF]	0.23	0.31	0.757
PTTC	0.10	0.43	0.666
RMTS	0.07	1.84	0.071
Ghost Task	0.08	1.43	0.157
Description Condition [Level 1 x PTTC	0.14	0.50	0.617
Description Condition [Level 2: (SGFF & SGUB) vs SOFF] x PTTC	0.12	-1.04	0.296
Description Condition [Level 1: SGFF vs SGUB] x RMTS	0.10	0.63	0.529
Description Condition [Level 2: (SGFF & SGUB) vs SOFF] x RMTS	0.09	-2.10	**0.036**
PTTC x RMTS	0.11	-0.26	0.790
Description Condition [Level 1: SGFF vs SGUB] x Ghost Task	0.11	-0.89	0.372
Description Condition [Level 2: (SGFF & SGUB) vs SOFF]x Ghost Task	0.09	0.41	0.679
PTTC x Ghost Task	0.04	-0.11	0.910
RMTS x Ghost Task	0.10	0.26	0.789
Description Condition [Level 1: SGFF vs SGUB] x PTTC x RMTS	0.15	-1.37	0.169
Description Condition [Level 2: (SGFF & SGUB) vs SOFF] x PTTC x RMTS	0.13	2.34	**0.019**
Description Condition [Level 1: SGFF vs SGUB] x PTTC x Ghost Task	0.06	0.33	0.736

Verbal Location Model

Fixed-Effects	ß(SE)	t	p
Description Condition [Level 2: (SGFF & SGUB) vs SOFF] x PTTC x Ghost Task	0.05	-1.85	0.064
Description Condition [Level 1: SGFF vs SGUB] x RMTS x Ghost Task	0.14	0.28	0.773
Description Condition [Level 2: (SGFF & SGUB) vs SOFF] x RMTS x Ghost Task	0.12	-0.14	0.883
PTTC x RMTS x Ghost Task	0.05	0.31	0.752
Description Condition [Level 1: SGFF vs SGUB] x PTTC x RMTS x Ghost Task	0.06	-0.63	0.526
Description Condition [Level 2: (SGFF & SGUB) vs SOFF]x PTTC x RMTS x Ghost Task	0.05	1.24	0.212

Verbal Action Model

Fixed-Effects	ß(SE)	t	p
(Intercept)	0.15	-0.006	0.995
Description Condition [Level 1: SGFF vs SGUB]	0.35	-1.95	0.081
Description Condition [Level 2: (SGFF & SGUB) vs SOFF]	0.30	-0.68	0.510
PTTC	0.08	-0.82	0.414
RMTS	0.06	2.02	**0.048**
Ghost Task	0.07	0.19	0.847
Description Condition [Level 1 x PTTC	0.13	0.55	0.577
Description Condition [Level 2: (SGFF & SGUB) vs SOFF] x PTTC	0.11	0.68	0.491
Description Condition [Level 1: SGFF vs SGUB] x RMTS	0.09	-0.38	0.699
Description Condition [Level 2: (SGFF & SGUB) vs SOFF] x RMTS	0.08	-2.55	**0.010**
PTTC x RMTS	0.09	-0.89	0.374
Description Condition [Level 1: SGFF vs SGUB] x Ghost Task	0.10	-0.66	0.507
Description Condition [Level 2: (SGFF & SGUB) vs SOFF]x Ghost Task	0.09	-0.16	0.870
PTTC x Ghost Task	0.04	0.57	0.565
RMTS x Ghost Task	0.08	1.11	0.270
Description Condition [Level 1: SGFF vs SGUB] x PTTC x RMTS	0.15	-2.02	**0.043**
Description Condition [Level 2: (SGFF & SGUB) vs SOFF] x PTTC x RMTS	0.13	0.68	0.497
Description Condition [Level 1: SGFF vs SGUB] x PTTC x Ghost Task	0.06	1.40	0.161
Description Condition [Level 2: (SGFF & SGUB) vs SOFF] x PTTC x Ghost Task	0.05	-2.49	**0.012**
Description Condition [Level 1: SGFF vs SGUB] x RMTS x Ghost Task	0.13	0.52	0.599
Description Condition [Level 2: (SGFF & SGUB) vs SOFF] x RMTS x Ghost Task	0.11	-0.75	0.448
PTTC x RMTS x Ghost Task	0.04	1.23	0.224
Description Condition [Level 1: SGFF vs SGUB] x PTTC x RMTS x Ghost Task	0.06	-0.06	0.945
Description Condition [Level 2: (SGFF & SGUB) vs SOFF]x PTTC x RMTS x Ghost Task	0.05	-1.60	0.109

Drawing Model

Fixed-Effects	ß(SE)	t	P
(Intercept)	0.12	0.03	0.971
Description Condition [Level 1: SGFF vs SGUB]	0.23	0.36	0.730
Description Condition [Level 2: (SGFF & SGUB) vs SOFF]	0.20	-0.64	0.538
PTTC	0.14	-0.29	0.773
RMTS	0.11	1.91	0.063
Ghost Task	0.11	0.87	0.389

Drawing Model Fixed-Effects	ß(SE)	t	P
Description Condition [Level 1 x PTTC	0.18	-0.20	0.839
Description Condition [Level 2: (SGFF & SGUB) vs SOFF] x PTTC	0.15	0.59	0.551
Description Condition [Level 1: SGFF vs SGUB] x RMTS	0.13	0.49	0.620
Description Condition [Level 2: (SGFF & SGUB) vs SOFF] x RMTS	0.12	0.13	0.896
PTTC x RMTS	0.18	-0.68	0.496
Description Condition [Level 1: SGFF vs SGUB] x Ghost Task	0.14	-0.05	0.953
Description Condition [Level 2: (SGFF & SGUB) vs SOFF]x Ghost Task	0.12	-1.58	0.113
PTTC x Ghost Task	0.14	1.35	0.182
RMTS x Ghost Task	0.13	-0.55	0.581
Description Condition [Level 1: SGFF vs SGUB] x PTTC x RMTS	0.23	-0.84	0.398
Description Condition [Level 2: (SGFF & SGUB) vs SOFF] x PTTC x RMTS	0.20	-0.36	0.714
Description Condition [Level 1: SGFF vs SGUB] x PTTC x Ghost Task	0.17	0.97	0.330
Description Condition [Level 2: (SGFF & SGUB) vs SOFF] x PTTC x Ghost Task	0.15	0.14	0.886
Description Condition [Level 1: SGFF vs SGUB] x RMTS x Ghost Task	0.16	-0.74	0.455
Description Condition [Level 2: (SGFF & SGUB) vs SOFF] x RMTS x Ghost Task	0.14	0.58	0.560
PTTC x RMTS x Ghost Task	0.22	-1.30	0.201
Description Condition [Level 1: SGFF vs SGUB] x PTTC x RMTS x Ghost Task	0.27	-0.66	0.508
Description Condition [Level 2: (SGFF & SGUB) vs SOFF]x PTTC x RMTS x Ghost Task	0.23	-0.61	0.542

Notes*. Bold typeface indicates a significant effect.*

2.5.2. Results

For spatial recall performance, the model revealed a significant main effect of description condition on the second level that compares speech-gesture combination conditions from both front-facing and upper-back perspectives compared to speech-only condition (ß = -0.33, SE = 0.13, p = 0.037). That is, children's verbal spatial information recall is enhanced in the speech-gesture combination conditions compared to the speech-only condition. See Figure 7. The model also revealed a significant interaction between PTT-C performance and the description conditions at the first level that compares multimodal conditions of front-facing and upper-back perspectives (ß = 0.29, SE = 0.14, p = 0.041). That is, when children's perspective-taking scores increase, their verbal spatial information recall is significantly enhanced in the speech-gesture front-facing condition (ß = 0.26, SE = 0.13, p = 0.05) compared to the speech-gesture upper-back condition (ß = -0.04, SE = 0.13, p = 0.78). See Figure 8. None of the other fixed effects or two- and three-way interactions were significant (ps > 0.05).

Figure 7. Children's verbal spatial recall in descriptive conditions

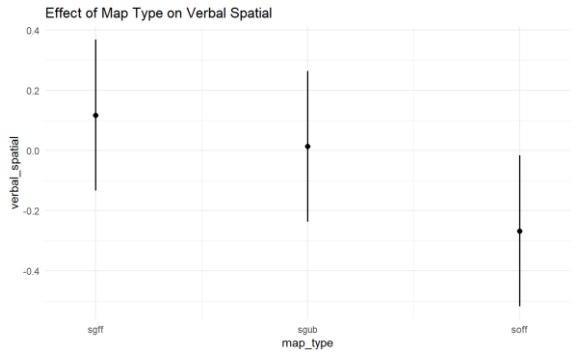
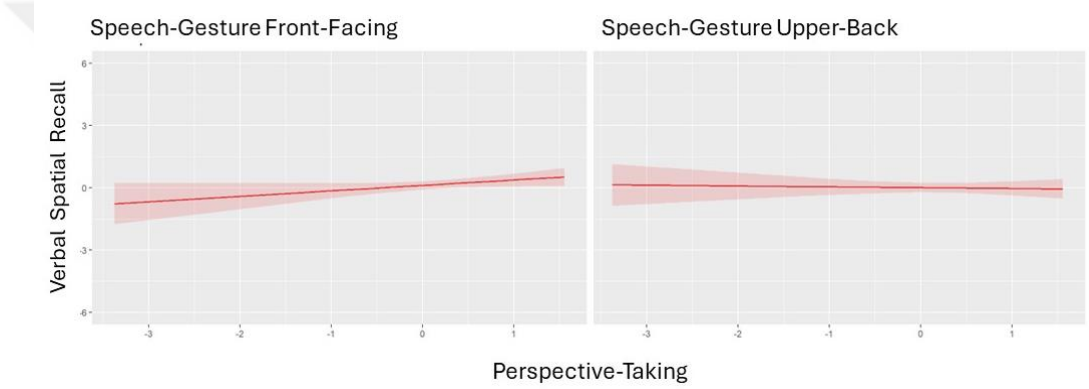


Figure 8. Children's recall performance as a function of perspective-taking performance and spatial recall when comparing multimodal conditions of front-facing and upper-back views



For location recall performance, the model revealed a significant interaction between RMTS performance and the description condition on the second level that compares speech-gesture combination conditions from both front-facing and upper-back perspectives compared to speech-only condition (ß = -0.19, SE = 0.09, p = 0.03). That is, when children's RMTS performance increases, their verbal location information recall is significantly enhanced in the speech-gesture combination conditions [SGFF (ß = 0.24, SE = 0.10, p = 0.02; SGUB (ß = 0.17, SE = 0.10, p = 0.08)] compared to speech-only condition (ß = 0.01, SE = 0.10, p = 0.88). The model also revealed a three-way interaction between PTT-C, RMTS, and the description condition on the second level that compares speech-gesture conditions from both front-facing and upper-back perspectives compared to speech-only condition (ß = 0.32, SE = 0.13, p = 0.02). That is, when children's perspective-taking scores are at (ß = 0.24, SE = 0.10, p = 0.02) or below the mean (ß = 0.49, SE = 0.21, p = 0.02), their verbal location information recall

in the speech-gesture front-facing condition is enhanced as a positive function of RMTS performance. None of the other fixed effects or two- and three-way interactions were significant for the location model (ps > 0.05).

For action recall performance, the model revealed a marginally significant main effect of RMTS performance (ß = 0.13, SE = 0.06, p = 0.048). When children's RMTS scores increase, their verbal action information recall also increases. The model also revealed a significant interaction between RMTS performance and description condition on the second level that compares speech-gesture conditions from both front-facing and upper-back perspectives compared to speech-only conditions (ß = -0.22, SE = 0.09, p = 0.01). That is, when children's RMTS performance increases, their verbal action information recall is enhanced when they receive multimodal directions in either front-facing (ß = 0.19, SE = 0.09, p = 0.03) and upper-back perspectives (ß = 0.23, SE = 0.09, p = 0.01) compared to directions including only speech. The model revealed a three-way interaction between PTT-C, RMTS, and the description conditions at the first level that compares multimodal conditions of front-facing and upper-back perspectives (ß = -0.3, SE = 0.15, p = 0.043). That is, when children's perspective-taking score is below the mean, they benefit from receiving directions in speech-gesture front-facing condition as a positive function of relational reasoning performance (ß = 0.46, SE = 0.18, p = 0.01); however, when their perspective-taking score is above mean they recall more information when they receive directions in speech-gesture upper-back condition and again as a positive function of relational reasoning performance (ß = 0.26, SE = 0.13, p = 0.04). The model also revealed another three-way interaction between the Ghost Task, PTT-C, and description condition on the second level that compares speech-gesture combination conditions from both front-facing and upper-back perspectives compared to speech-only condition (ß = -0.13, SE = 0.05, p = 0.01). However, post-hoc analyses of the interaction did not reveal any significant results (ps > 0.05). None of the other fixed effects or two- and three-way interactions were significant for the action model (ps > 0.05).

For children's drawing performance, none of the fixed effects or two- and three-way interactions were significant (ps > 0.05).

CHAPTER 3

DISCUSSION

Children's spatial performance on visuospatial maps was investigated by considering the interaction between children's spatial abilities and variations in speaker presentation conditions and gesture use. We consider perspective-taking, relational reasoning, and mental rotation abilities as children's spatial abilities. Variations in presentation conditions and gesture use were administered by providing route descriptions in speech-only front-facing, speech-gesture front-facing, and speech-gesture upper-back view.

Overall, results showed that children's verbal recall performance was enhanced when they received descriptions multimodally compared to speech-only descriptions. When considering the perspective of multimodal presentation, children benefit more from receiving directions in speech-gesture front-facing condition than speech-gesture upper-back condition. Among children's spatial abilities, perspective-taking and relational reasoning abilities are the most crucial in predicting their recall performance across all types of verbal recall. Lastly, several interactions between internal (perspective taking, relational reasoning) and external (presentation perspective, multimodality) sources were found to be modulating the children's verbal but not necessarily behavioral recall performance. In the following sections, we will discuss each of these findings with respect to how and to what extent they corroborate previous evidence and/or extend them in novel ways.

3.1. Multimodal descriptions enhance children's verbal recall performance

Comparing children's verbal recall performance based on descriptive conditions, we observed a considerable effect of multimodal presentation, including speech and gesture. In all types of recall, children benefit from receiving route descriptions

multimodally presented on a tablet screen compared to speech-only presentation. These results align with the literature considering the contribution of presenting descriptions with gestures to children's spatial performance. Austin and Sweller (2014) provided route descriptions on a visuospatial map and suggested that using gestures enhances children's recall of spatial information better compared to adults; Kartalkanat and Göksun (2020) provide gestures during storytelling and conclude that children and adults better recall stories presented with iconic gestures. Similar to our study, Austin and Sweller (2014) provided a visuospatial map, although we presented it on a tablet screen. Both studies evaluated verbal recall by considering specific types of information, such as location and event, as we investigated. Although we did not include an adult sample, our results support the current literature by showing the considerable contribution of multimodal descriptions and expanding it while highlighting the nuanced interactions between internal and external sources of gesture comprehension.

Moreover, our results contribute to the literature by demonstrating evidence for multimodal presentation from different perspectives, either from a front-facing or upper-back perspective. To our knowledge, multimodal presentation from an upper-back perspective has not been included in the descriptions directed to children before. This is the first study that included gestures from an upper-back perspective, which explored its relation with children's spatial abilities and recall performance on visuospatial maps.

Particularly for the speech-gesture upper-back condition, we found that when children's perspective-taking scores are higher than the mean, their high relational reasoning abilities enhance children's verbal action recall performances in the speech-gesture upper-back condition. By contrast, in the speech-gesture front-facing condition, the relation between relational reasoning and action information recall was observed only for perspective-taking scores at or below the mean. That is, higher perspective-taking abilities are associated with better action recall performance when gestures are presented from an upper-back angle in the descriptions. These findings demonstrate that better recall performance after receiving directions in speech-gesture

upper-back conditions is modulated by higher perspective-taking abilities, and comprehension of action-encoded gestures from an upper-back perspective requires better perspective-taking abilities.

Our findings on action information recall show some similarity between the suggestions of Hostetter et al. (2018) that seeing gestures aligned with the audience perspective enhances task performance. However, compared to Hostetter et al. (2018), we did not flip the materials to align the speaker's gestures with the listener's perspective; we manipulated the speaker's perspective for the task precisely. Moreover, our findings also relate to the results of Hinterwimmer et al. (2021), manipulating the narrative perspective of the speaker's gestures and suggesting that the presentation of gestures from the observer or character point-of-view does not relate differently. We did not manipulate the gesture presentation considering the observer's or character's perspectives; the speaker's descriptions were based more on the observer's view. However, we did not find a positive effect in seeing gestures from the upper back angle for spatial and location information recall. This indicates that multimodal input and perspective affect children's spatial performances differently depending on the type of information (spatial, location, or action) and emphasizes the importance of elaborating spatial abilities across varied dimensions rather than as a whole.

While investigating children's recall performances considering the description conditions in the directions task, we also consider children's behavioral recall performances. During the directions task, children verbally recalled and then drew the route after each description. However, their drawing responses were not associated with their spatial abilities or presentation conditions, which shows that internal and external sources relate to children's verbal but not necessarily behavioral recall performance. While investigating the effect of gesture presentation on children's recall of route descriptions on a tangible visuospatial map, Austin and Sweller (2014) asked children to verbally recall and show the route on the visuospatial map using a toy figure. Their results showing the contribution of multimodal input during route description on children's performance were based on verbal and behavioral recall together. In contrast, our visuospatial maps were presented on a screen, and children

drew the route on a printed version, which they were not able to experience the visuospatial map physically. Our results show considerable insight by evaluating verbal and behavioral recall separately and underlining the importance of multimodal input during verbal but not necessarily behavioral recall. It can also be concluded that gesture use during spatial descriptions is more effective for verbal recall, and visual cues during behavioral recall can compensate for the speech-only condition and balance the descriptive conditions' effect.

3.2. Perspective-taking and relational reasoning abilities predict children's verbal recall performance

Our results demonstrated that children's perspective-taking abilities relate to children's verbal recall of spatial information. We observed perspective-taking abilities interacting with the description conditions regarding all types of information recall: spatial, location, and action.

Particularly for children's location and action information recall performances, we observed that their lower perspective-taking scores interact with higher relational reasoning abilities and enhanced verbal recall in speech-gesture front-facing conditions. This shows that, when children's perspective-taking abilities are low, they can benefit from multimodal presentation and as a positive function of relational reasoning abilities. Moreover, this interaction between perspective-taking and relational reasoning abilities is observed only in location and action recall in speech-gesture front-facing conditions but not necessarily in recalling spatial information. For verbal spatial information recall, we found that children's higher perspective-taking performance increases their recall performance in speech-gesture front-facing conditions. These results demonstrate the importance of perspective-taking ability while comprehending and interpreting spatial information. Conversely, our results also demonstrated for the first time that when recalling location and action information, higher perspective-taking ability is not required in speech-gesture front-facing condition since enhanced relational reasoning abilities can modulate children's lower perspective-taking scores.

This result supports our prediction, considering previous findings demonstrated how speech and gesture combination during the descriptions of analogical reasoning tasks relate to 4 to 11-year-old children (Guarino & Wakefield, 2020). They illustrated the unique enhancement of 5-year-olds' performances in multimodal descriptions. Our results extend their findings by elaborating that relational reasoning is a considerable internal source for gesture comprehension, facilitating children's performances. Highlighting the age group, our results also contribute to their finding that 5-year-olds perform better when descriptions include gestures.

Finally, we also observed a unique relation between higher perspective-taking skills and speech-gesture upper-back condition while encoding action information. Higher perspective-taking and relational reasoning abilities of children relate to higher action recall performance in speech-gesture upper-back conditions, unlike front-facing conditions. It seems that during the comprehension of action gestures, seeing gestures from the upper-back perspective requires higher perspective-taking skills, while the front-facing perspective does not. It can also be interpreted as children with higher perspective-taking skills can comprehend more complex multimodal input in terms of perspective.

3.3. Limitations and future directions

Our study contributes to the literature in terms of evaluating internal and external sources of gesture comprehension with preschool children's spatial performances. It was the first study investigating the issue from a gesture presentation perspective, considering an upper-back angle. Moreover, it was also the first one to use an online education presentation to assess children's performances on visuospatial maps that were presented on the screen. However, the visuospatial maps in our task were 2D maps, and children could not experience the maps, which limited our predictions compared to studies that used tangible maps, 3D maps, and maps used with virtual reality devices. Further studies could investigate internal and external sources of gesture comprehension by considering children's spatial performances on tangible or 3D visuospatial maps and comparing verbal and behavioral recall performances to illustrate the relation between visuospatial maps and recall type.

While presenting videos of route directions, we did not include the face of the speaker. In the speech-gesture upper-back condition, the speaker's face was invisible, and to balance the description conditions, we also did not include the speaker's face in the speech-gesture front-facing and speech-only conditions. Although the literature suggests that the audience benefits from the speaker's visible speech (Schubotz et al., 2020), the speaker's gesture is also shown to enhance the audience's comprehension even when the speaker's gaze is averted (Holler et al., 2014). Thus, the invisible face of the speaker might limit our results.

Our suggestions are limited to internal and external sources of gesture comprehension related to only children's spatial performances. Unlike previous studies on gesture comprehension and spatial performances, we did not compare an adult sample with children. However, it is essential to consider different age groups to understand better the developmental factors contributing to the comprehension of multimodal input in visuospatial tasks. Previous studies (Austing & Sweller, 2014) highlighted a significant age difference, showing that children benefit more from multimodal directions than adults on visuospatial tasks. Further studies can also evaluate the variations in internal and external sources between children and adult samples to illustrate the differences in spatial performances better. Based on the literature and our findings, adults would not be expected to show significantly different verbal recall performance between description conditions. However, further investigation into how internal and external sources during verbal recall relate to adults' performance can provide considerable insight.

Our suggestions are also limited to internal and external sources of only gesture comprehension related to children's spatial performances. Although children's gesture use is found to be related to their spatial performance (Miller et al., 2020), children's gesture production has not been investigated in this study. Thus, further studies should also examine the interaction between children's spatial performances and internal and external sources of gesture production.

Children's language abilities are suggested to predict their spatial abilities (Loewenstein & Gentner, 2005; Simms & Gentner, 2019). While evaluating the

relationship between spatial abilities and gestures, our study was not comprehensive for children's general language abilities. Their language abilities can predict their performances in our directions task. Children with higher language skills may not show varied performances in different descriptive conditions, and children with lower language skills may benefit from multimodal descriptions more. Further studies can also consider children's general language abilities while showing children multimodal descriptions to illustrate better how children benefit from gestures.

Finally, during our assessment of the directions task, children engaged in passive learning with a tablet screen since the speaker was absent. Previous research findings demonstrated how adults can benefit from passive learning during spatial acquisition (Qui et al., 2020), and our results support their findings by showing that children can also benefit from passive learning strategies on spatial navigation tasks. However, further studies can also investigate the passive and active learning strategies to evaluate children's performance in spatial navigation tasks.

3.4. Conclusion

The study investigated the relationship between children's spatial performances and gesture comprehension by evaluating internal and external factors. For internal sources, perspective-taking, mental rotation, and relational reasoning abilities have been considered, and for external sources, multimodal descriptions and their perspective have been manipulated. Results showed that children benefit more from descriptions that include both speech and gesture from a front-facing perspective. Specifically, multimodal descriptions enhance children's verbal but not necessarily behavioral recall. Moreover, children's perspective-taking and relational reasoning abilities modulate the interaction between their gesture comprehension and visuospatial task performances.

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APPENDICES

A. APPROVAL OF THE METU HUMAN SUBJECTS ETHICS COMMITTEE

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MIDDLE EAST TECHNICAL UNIVERSITY

19 HAZİRAN 2023

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Dr. Dilay Zeynep Karadöller Astarlıoğlu

Danışmanlığını yürüttüğünüz Elif Orakçı'nın ***"Anlatıcı koşulları çocukların dil üretimini ve yön takip etme davranışlarını nasıl etkiler?"*** başlıklı araştırmanız İnsan Araştırmaları Etik Kurulu tarafından uygun görülerek **308-ODTUİAEK-2023** protokol numarası ile onaylanmıştır.

Bilgilerinize saygılarımla sunarım.

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Başkan

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B. ROUTE DESCRIPTIONS IN THE DIRECTIONS TASK

The Directions Task Route Descriptions in Turkish

1. Eda evin önünde dururken bir kedi gördü. Evin karşısına geçerek gördüğü kediyi sevdi. Sonra evin ve kaydırağın önünden yürüyerek okula gitti.
2. Ali okuldan çıktıktan sonra parka doğru yürümüş. Yolun karşısına geçip kaydıraktan kaymış. Kaydıraktan kaydıktan sonra düz ilerlemiş koşarak eve gitmiş.
3. Ayşe bir gün bir kediyle oynuyormuş ve daha sonra yolun karşısına geçerek pazara gitmiş. Pazardan alışveriş yaptıktan sonra çok yorulmuş. Pazarın yanındaki kayaların üzerinde oturup dinlenerek etrafı izlemiş.
4. Selma bir gün havuzun karşısında bir baloncu görrmüş. Bir balon alıp zıplayarak masanın önünden ilerlemiş. Elma ağacının yanındaki yoldan yürüyerek evine gitmiş.
5. Selim büyük bir ağaçtan elma toplamış. Topladığı elmalarla yolun karşısına geçerek masaya oturmuş. Masada elmaları yedikten sonra dondurmacıya doğru yürümüş.
6. Ahmet bir gün evin karşısındaki dondurmacıdan dondurma almış. Dondurmayı yiyerek ağacın önünden yürümüş. Ağacın yanındaki yoldan geçerek havuzda yüzmüş.
7. Sude bankın önünde zıplıyormuş. Sonra yolun karşısında geçerek dönme dolaba binmiş. Dönme dolaba bindikten sonra dönme dolabın yanındaki çiçekleri toplamış.
8. Emre pastanenin önünde pastalara bakıyormuş. Sonra evin önünden geçerek yürümüş ve bankta oturmuş. Bankta dinlendikten sonra çiçeklerin karşısındaki evine gitmiş.
9. Burak bir gün salıncakta sallanıyormuş. Çok yorulup pastanenin önünden geçerek eve gitmiş. Evde dinlendikten sonra çiçeklerin yanından geçerek dönme dolaba binmek için koşarak gitmiş.

The Directions Task Route Descriptions in English

1. Eda stood in front of the house and saw a cat. She crossed to the opposite side of the house and petted the cat she saw. Then, she walked in front of the house, slid, and went to school.
2. After Ali left school, he walked towards the park. He crossed the street and slid down the slide. After sliding down the slide, he ran straight ahead and went home.
3. One day, Ayşe was playing with a cat. Later, she crossed the street to go to the market. After shopping at the market, she became exhausted. She sat on the rocks next to the market while resting and watching around.
4. Selma saw a balloon seller across from the pool one day. She bought a balloon and moved forward by jumping past the table. She walked home along the road next to the apple tree.
5. Selim picked apples from a big tree. He crossed the street with the apples he picked and sat at the table. After eating the apples at the table, he walked towards the ice cream shop.
6. Ahmet bought ice cream from the truck opposite the house. He walked past in front of the tree while eating the ice cream. Then, he passed behind the tree and swam in the pool.
7. Sude was jumping in front of the bench. Then she crossed the street and got on the ferris wheel. After riding the ferris wheel, she picked flowers next to it.
8. Emre was looking at cakes in front of the bakery. Then he walked past the house and sat on a bench. After resting on the bench, he went to his house across the flowers.
9. One day, Burak was swinging on the swing. He got very tired and walked past the bakery to go home. After resting at home, he ran past the flowers to ride the ferris wheel.

C. INFORMED CONSENT

Veli Onay Formu
Sevgili Anne/Babalar,
Bu çalışma Orta Doğu Teknik Üniversitesi Psikoloji Bölümü Dr. Öğretim Üyesi Dilay Z. Karadöller Astarlıoğlu danışmanlığında Gelişim Psikolojisi yüksek lisans öğrencisi Psikolog Elif Orakçı tarafından yürütülmektedir.

Bu çalışmanın amacı nedir?

Çalışmanın amacı, anlatıcıların çocuklara yol tarifi verirken kullandıkları jestlerdeki farklılıkların çocukların uzamsal becerilerine etkisini araştırmaktır.

Çocuğunuzun katılımcı olarak ne yapmasını istiyoruz?

Bu amaç doğrultusunda, çocuklara tablet/dizüstü bilgisayardan haritalar göstereceğiz. Haritaların sağ üst köşesinde online eğitime benzer şekilde, bir anlatıcı çocuklara yol tarifi anlatacaktır. Daha sonrasında çocukların bu yol tarifini sözel olarak ifade etmelerini ve önlerinde basılı bularak harita üzerinden yol tarifini çizmelerini isteyeceğiz. Bununla beraber çocukların ifade edici dil, perspektif alma, ilişkisel eşleştirme ve zihinsel dönüş becerilerine yönelik uygulamalar yapacağız. Çalışma esnasında ses ve görüntü kaydı alınacak olup çalışma her çocukla bireysel olarak gerçekleştirilecektir. Sizden çocuğunuzun katılımcı olmasıyla ilgili izin istediğimiz gibi, çalışmaya başlamadan çocuğunuzdan da sözlü olarak katılımıyla ilgili rızası mutlaka alınacak.

Çocuğunuzdan alınan bilgiler ne amaçla ve nasıl kullanılacak?

Çocuğunuzdan alacağımız cevaplar tamamen gizli tutulacak ve sadece araştırmacılar tarafından değerlendirilecektir. Elde edilecek bilgiler sadece bilimsel amaçla yüksek lisans tezi için kullanılacak, çocuğunuzun ya da sizin ismi ve kimlik bilgileriniz, çalışma esnasında alınacak ses ve görüntü kaydı hiçbir şekilde kimseyle paylaşılmayacaktır.

Çocuğunuz ya da siz çalışmayı yarıda kesmek isterseniz ne yapmalısınız?: Katılım sırasında sorulan sorulardan ya da herhangi bir uygulama ile ilgili başka bir nedenden ötürü çocuğunuz kendisini rahatsız hissettiğini belirtirse, ya da kendi belirtmese de araştırmacı çocuğun rahatsız olduğunu öngörürse, çalışmaya sorular tamamlanmadan ve derhal son verilecektir.

Bu çalışmayla ilgili daha fazla bilgi almak isterseniz: Çalışmaya katılımınızın sonrasında, bu çalışmayla ilgili sorularınız yazılı biçimde cevaplandırılacaktır. Çalışma hakkında daha fazla bilgi almak için Gelişim Psikolojisi yüksek lisans öğrencisi Psikolog Elif Orakçı ile (e-posta:) ile iletişim kurabilirsiniz. Bu çalışmaya katılımınız için şimdiden teşekkür ederiz.

Yukarıdaki bilgileri okudum ve çocuğumun bu çalışmada yer almasını onaylıyorum (Lütfen alttaki iki seçenekten birini işaretleyiniz.

Evet onaylıyorum___ Hayır, onaylamıyorum___
Velinin adı-soyadı: _____ Bugünün Tarihi:_____

D. TURKISH SUMMARY / TÜRKÇE ÖZET

BÖLÜM 1

GİRİŞ

COVID-19 dönemiyle birlikte geleneksel eğitim sistemi, çevrimiçi eğitime uyum sağlarken (Umeta ve ark., 2022; Tadesse & Muluyye, 2020), insan etkileşiminin sınırlanması sebebiyle çevrimiçi eğitimden en çok etkilenen grup çocuklar olmuştur (Parlakkilic, 2021). Çevrimiçi ortamlarda bilgi sunarken konuşmacının dili ve jest kullanımı gibi dışsal faktörlerle perspektif alma, zihinsel döndürme ve ilişkisel akıl yürütme becerileri gibi içsel faktörler dinleyicilerin bilgiyi kavrayışını doğrudan etkileyebilir. Daha önceki çalışmalar görsel-uzamsal yönergeleri sözel dil ve jestle birlikte aktarmanın çocukların uzamsal anlayışları üzerinde önemli bir etkisi olduğunu göstermiştir (Austin & Sweller, 2014). Ancak bu sonuçlar çevrimiçi bağlamlara genellenemediği gibi güncel çevrimiçi eğitim araçlarında yer alan konuşmacının jestlerindeki perspektif değişimlerini de kapsamamaktadır. Bu çalışmada, 5 yaş çocuklarının uzamsal becerileriyle multimodal dil girdisinin perspektifi arasındaki etkileşim incelenmiştir. Bunun için, çocuklara ekran üzerinden görsel-uzamsal haritalarla birlikte multimodal dil girdisi ve perspektifi değişen konuşmacı koşulları gösterilmiştir. Çocuklardan konuşmacının yol tariflerini sözel olarak tekrar etmeleri ve harita üzerinden göstermeleri beklenmiştir.

Uzamsal Kavrama ve Yön Bulma

Uzamsal kavrama, dünyayı keşfetmeye ve çevrenin farkına varmaya katkı sağlayan uzam, hareket, şekil, yer-yön ve pozisyon gibi kavramları kapsayan bir bilişsel beceridir (örneğin, Hund ve ark., 2021; Uhlenberg & Geiken, 2021; Young ve ark., 2018).

Erken çocuklukta, uzamsal kavrama uzamsal dil ile birlikte gelişir (Clingan-Siverly ve ark., 2021; Gentner ve ark., 2013; Hund ve ark., 2021). Uzamsal dil kullanımı, okul öncesi dönemdeki çocukların uzamsal ilişkisel haritalama görevlerindeki

performanslarını arttırdığı gibi mevcut ve gelecekteki uzamsal becerilerini de öngörür. (Loewenstein & Gentner, 2005; Simms & Gentner, 2019). Mevcut çalışmalar uzamsal dilin etkisinin sözel dile indirgenemeyeceğini, jestler gibi sözel olmayan dil unsurlarının da uzamsal kavramayı etkilediğini göstermektedir. Jest kullanımı ve uzamsal kavrama arasındaki ilişkiyi yetişkinlerde inceleyen çalışmalar, konuşma ögesi uzamsal bilgi içerdiğinde jest kullanımının yetişkinlerin kavrayışını doğrudan etkilediğini ve sözel dille birlikte jest kullanmanın uzamsal bilginin işlenmesine katkıda bulunduğunu göstermiştir. (Brooks ve ark., 2018; Driskell & Radtke, 2003; Göksun ve ark., 2013; So ve ark., 2015). Yetişkinlerin yanı sıra, uzamsal anlatımlarda jest kullanımı çocukların da güvenlikleri ve yaşam boyu bağımsızlıkları için hayati öneme sahip olan uzamsal kavrama ve yön bulma becerilerini etkiler (Gazova ve ark., 2013). Konuyu çocuklar açısından değerlendiren az sayıdaki çalışma, çocukların jest kullanımı uzamsal analojilerle ilişkili performanslarını yordadığını (Miller ve ark., 2020); sözel hatırlama ve yer-yön bulma performanslarını arttırdıklarını göstermiştir (Austin & Sweller, 2017). Çocuk ve yetişkin grupları karşılaştıran çalışmalar da rota tarifinde bulunurken çocukların yetişkinlerden daha az jest kullanırken aynı zamanda yetişkinlerden daha fazla ikonik jeste yer verdiğini göstermiştir (Austin & Sweller, 2018). Bunun yanı sıra, görsel-uzamsal haritalar kullanılarak yapılan uzamsal tariflere jestler eşlik ettiğinde çocukların yetişkinlere göre jestlerden daha fazla faydalandığı; mekân ve hareket içeren bilgileri daha iyi hatırladıkları gözlemlenmiştir (Austin & Sweller, 2014). Yetişkin ve çocuk gruplarının sözel hatırlama becerilerini rota içerikli hikayeleri jest sunum koşullarını manipüle ederek sunan başka bir çalışma da yetişkin ve çocukların ikonik jestlerin dahil edildiği hikâye içeriklerinde daha iyi performans gösterdiğini vurgulamıştır. Bu çalışmalar yetişkin ve çocukların, özellikle de çocukların uzamsal kavrayışlarında sözel dil ve jestlerin önemli etkisini vurgulamaktadır.

Dijital çağla birlikte uzamsal kavrama ve yön bulma çalışmaları, fiziksel ortamlarda yürütülen araştırmaların daha fazla kaynak gerektirmesi nedeniyle çevrimiçi bağlamları da kapsamaya başlamıştır (Qiu ve ark., 2020). Çalışmalar, değişken yaş gruplarını (Gyselinck ve ark., 2013; Nys ve ark., 2018), görsel boyutları (Sampaio ve ark., 2017; Weisberg ve ark., 2014), insan etkileşimlerini (Pouliquen-Lardy ve ark., 2015) ve öğrenme metodolojilerini ele alarak çevrimiçi ortamlarda uzamsal

becerileri incelemiştir. Ancak, bu sonuçlar çocukların uzamsal becerileriyle dil ve jest kullanımlarındaki varyasyonlar arasındaki etkileşimi kapsamamaktadır. Önceki çalışmalar, jestlerin uzamsal kavrama ve uzamsal, mekânsal ve eylem bilgilerin tanınması üzerindeki önemli etkisini vurgulamıştır. Bu sebeple, çalışmada bir konuşmacının jest kullanımının ve jestlerinin perspektifinin manipüle edilmesi amaçlanmış, konuşmacının yol tariflerinin çocukların uzamsal kavrama becerilerine olan etkisi çocukların sözel ve davranışsal boyuttaki hatırlama becerileri üzerinden değerlendirilmiştir. Ancak öncelikle jestlerin kavranışını etkileyen içsel ve dışsal faktörlerin değerlendirilmesi ve jestlerin perspektifindeki değişikliğin bu ilişkiyi nasıl etkileyebileceğinin ele alınması önem taşımaktadır.

Jest Kavrama

Jestler, görünür konuşmanın kavranışını arttıran insan etkileşimindeki dilin temel unsurlarından biridir. (Drijvers & Özyürek, 2017). Jest üretimi ve anlama süreçleri iletişim bağlamı, görev özellikleri gibi dışsal kaynaklar ve yaş, kişilik, bilişsel ve algısal beceriler gibi içsel kaynaklar tarafından şekillenir (Özer & Göksun, 2020). İçerik ve bağlam odaklı dışsal faktörler ele alındığında jest üretimi ve anlama süreçlerinin konuşmacı ve dinleyici özelliklerinden etkilendiği görülür. Konuşmacılar mesajlarının içeriklerini dinleyicinin yaşına ve bilgisine göre adapte ederler (örneğin, Campisi & Özyürek, 2013; Clark & Estigarribia, 2011). Yetişkinler çocuklara yeni şeyler aktarırken çocukların dikkatinin devamlılığını sağlayabilmek için daha tutarlı jestler kullanırlar (Clark & Estigarribia, 2011). Bununla birlikte bir çocukla iletişimde olduğunu hayal eden yetişkinler, bir yetişkinle iletişim kurduklarını varsaydıkları bir senaryoya göre daha detaylı ve zengin ikonik jestler kullanırlar (Campisi & Özyürek, 2013). Yetişkinler aynı zamanda karşılarındaki dinleyicinin bilgi düzeyine karşı duyarlıdırlar ve dinleyicileri yaşlılar olduğunda ve mesaj içeriği dinleyiciler için aşina olmadığında daha fazla jest kullanırlar (Schubotz ve ark., 2015). Çalışmalar konuşmacının multimodal dil kullanımının özellikle çocuk dinleyiciler için önemli olduğunu gösterirken çocukların dilin multimodalitesinden ne derecede faydalandıkları detaylı olarak araştırılmamıştır.

Dinleyici odaklı çalışmaların yanı sıra jest çalışmaları aynı zamanda konuşmacı odaklı faktörlerin jestlerin kavranışını nasıl etkilediği üzerine de yoğunlaşmıştır.

Konuşmacının göz temasının sözel dil ve el jestlerinin farklı kombinasyonlarıyla manipüle edildiği bir çalışmada, konuşmacının sözel dil ve jest kullanımının göz temasının olmadığı durumlarda dahi dinleyicilerin anlayışını olumlu şekilde etkilediği gösterilmiştir (Holler ve ark., 2014). Konuşmacının görünür konuşmasının, sesinin netliğinin ve jest kullanımının manipüle edildiği başka bir çalışmada, konuşmacının sesinin bozuk olduğu koşullarda genç ve yaşlı yetişkinlerin jest ve görülebilir konuşmadan faydalandığı gözlemlenmiştir (Schubotz et al., 2020).

İçsel kaynaklara odaklanıldığında, perspektif-alma, mental döndürme ve ilişkisel akıl yürütme gibi bilişsel becerilerin de jest üretimi ve anlama düzeylerini etkilediği görülür. Farklı bakış açılarından değerlendirme becerisi olan perspektif alma becerisi (Frick ve ark., 2014) jest anlama süreci için önemli bir içsel kaynak olup güncel çocuk odaklı eğitim çalışmalarında önemli bir odak noktası da olmuştur (Yadollahi ve ark., 2020). Jest ve perspektifi değerlendiren çalışmalar, birinci şahıs, ikinci şahıs ve üçüncü şahıs bakış açılarını içerir (Zhang ve ark., 2018) ve benmerkezci bir perspektiften yapılan jestler sosyal etkileşimlerde nöral işlemi bile artırabilir (Nagels ve ark., 2015). Jest sunum perspektifi, görev performansını da etkileyebilir; jestlerin perspektifi dinleyicinin değil de konuşmacının perspektifiyle uyumlu olduğunda, görev anlama daha karmaşık hale gelir (Hostetter ve ark., 2018). Öte yandan, jestler anlatımın içeriğindeki karakter ve gözlemci perspektifine odaklanarak manipüle edildiğinde belirli bir perspektiften çok jestlerin bilgi vericiliğinin daha önemli olduğu gösterilmiştir (Hinterwimmer ve ark., 2021).

Mental rotasyon uzamsal bilişin en önemli uzantılarından biri olup nesneleri zihinsel olarak döndürmenin bilişsel sürecini kapsar (Frick ve ark., 2013). Bu konudaki literatürdeki socunçlar, jestlerin mental rotasyon görevlerinde çocukların (Goldin-Meadow ve ark., 2012; Levine ve ark., 2018) ve yetişkinlerin problem çözme yeteneklerini geliştirdiğini göstermiştir (Çapan ve ark., 2024; Chu & Kita, 2011). İlişkisel akıl yürütme becerileri de günlük ve bilimsel akıl yürütme becerilerinin yapı taşı olup insanın zihinsel kapasitesini diğer türlerden ayırır ve jestlein kavranışını etkiler (Christie & Gentner, 2014; Kroupin & Carey, 2021). İlişkisel akıl yürütme becerisi, jest kullanımının miktarını, şeklini ve bağlantılılığını etkiler (Cooperrider ve ark., 2016), ve içeriklerin jestle birlikte sunulması, karmaşık öğeleri daha açık hale getirerek çocukların analojik akıl yürütme ve problem çözme yeteneklerini de artırır

(Guarino & Wakefield, 2020).

Son zamanlarda jestlerin kavranışının da sanal ortamlarda (Godwin-Jones, 2023) ve insan-bilgisayar etkileşimi (Papanagiotou ve ark., 2021), VR cihazları (Zhang ve ark., 2018) ve giyilebilir kameralar (Bandini & Zariffa, 2023; Garcia del Molino ve ark., 2016) içeren çalışmalarda incelendiği görülmektedir. Sanal ortamlarda jest görünümüne odaklanan bu çalışmalar, jestlerin uzamsal performansla olan etkileşimini ve çocuklara yönelik çevrimiçi eğitim araçlarında güncel sunumların önemini vurgular. Ancak, bu çalışmalar çocuklar için daha kapsayıcı olmalı ve uzamsal performans ile dilin multimodalitesi arasındaki ilişkiye odaklanmalıdır.

Mevcut Çalışma

Literatür, uzamsal anlama ve jest kavrayışının arasındaki ilişkinin içsel ve dışsal kaynaklardan etkilendiğini önemli ölçüde göstermiştir. Bu çalışmada, çocukların içsel performanslarından perspektif alma, mental rotasyon ve ilişki kurma yeteneklerini test etmeyi ve konuşmacının jest kullanımı ve jest sunum perspektifi gibi dışsal faktörleri deneysel olarak değiştirilmesi hedeflenmiştir (ön-yüz görünümünden sadece konuşma koşulu, ön-yüz görünümünden konuşma ve jest kombinasyonu, ve üst-arka açıdan konuşma ve jest kombinasyonu).

Çalışmada farklı perspektifler ve multimodal anlatımlarla görsel-işitsel haritalar ve rota tarifleri sunulmuştur. Çocuklardan rotayı sözel olarak tarif etmeleri ve harita üzerinde tarif edilen yolu çizmeleri istenmiştir. Çocukların sözel hatırlama performansı, hatırlanan bilgi türleri (uzamsal, mekânsal ve eylemsel) dikkate alınarak değerlendirilmiştir (Austin & Sweller, 2014; Kartalkanat & Göksun, 2020). Çocukların genel bilişsel ve uzamsal yetenekleri (perspektif alma, mental rotasyon ve ilişki kurma) de görsel-işitsel haritalar üzerindeki performanslarına olan etkisini incelemek için değerlendirilmiştir.

Mevcut literatürde jest kullanımının çocukların uzamsal anlayışını artırdığı göz önüne alındığında (Austin & Sweller, 2014; Austin & Sweller, 2017, 2018; Miller ve ark., 2020), çocukların jest ve konuşma birlikte sunulduğunda sözel hatırlama performanslarının, yalnızca sözel dil sunumuna göre anlamlı ölçüde daha iyi olacağı öngörülmektedir. Özellikle, Austin ve Sweller (2014) çalışması göz önüne alındığında, çocukların çizim davranışı ve sözel hatırlama performanslarının, ön-yüz

görünümünden konuşma ve jest kombinasyonu koşulunda, yalnızca konuşma koşuluna göre daha iyi olması beklenmiştir. Ancak, üst-arka açıdan jest ve konuşma sunmanın diğer koşullara kıyasla nasıl bir fark yaratacağına dair herhangi bir öngörü yapılmamıştır.

Çocukların uzamsal performanslarının, jest kullanımı ve sunum perspektifi ile etkileşerek hatırlama performanslarında farklılıklara yol açması beklenmiştir. İlk olarak, dinleyicinin perspektifiyle uyumlu jestleri görmenin görev performansına olumlu etkisi olabileceğinden (Hostetter ve ark., 2018; Nagels ve ark., 2015), çocukların perspektif alma yetenekleri ile sözel hatırlama performansları arasında, üst-arka açıdan jest ve konuşma koşulunda anlamlı bir etkileşim beklenmiştir. Çocukların perspektif alma, mental rotasyon ve ilişkisel akıl yürütme becerilerinin konuşma ve jest kombinasyonu koşulları altında görsel-uzamsal haritalar üzerindeki sözel ve davranışsal hatırlamalarına olan etkilerinde, çocukların becerileri arasında etkileşim görülmesi beklenmiştir.

BÖLÜM 2

YÖNTEM

Araştırmanın etik onayı Orta Doğu Teknik Üniversitesi İnsan Araştırmaları Etik Kurulu'ndan (308-ODTUİAEK-2023) ve Milli Eğitim Bakanlığı'ndan (54850036-605.01-E.527) alınmıştır. Araştırmaya Türkiye'de yaşayan, tek dilli Türkçe konuşan 52 çocuk (29 kız, yaş ortalaması = 69 ay, SD = 9,2) katılmıştır. Engelli, dil gecikmesi olan ve psikiyatrik ilaç kullanan çocuklar çalışmaya dahil edilmemiştir. Katılımcıların demografik bilgileri ebeveynlerden toplanmıştır; annelerin %78,85'inin lisans ve üzeri eğitime sahip olduğu, %11,54'ünün lise mezunu olduğu ve %15,38'inin liseden az eğitime sahip olduğu belirlenmiştir. Ailelerin %36'sı yüksek gelirli, %42'si orta gelirli ve %26'sı düşük gelirli olarak tanımlanmıştır. Çocukların %98'i günlük olarak tablet, telefon veya bilgisayar kullanmaktadır. Çocukların görsel-uzamsal performanslarını ölçmek için Harita Görevi kullanılmış üç farklı harita, konuşma ve konuşma-hareket kombinasyonları ile sunulmuş, çocukların yanıtları sözlü olarak tanımlamaları ve harita üzerine çizmeleri

istenmiştir. Perspektif alma becerilerini değerlendirmek için PTT-C (Frick ve ark., 2014; Frick & Pichelmann, 2023) görevi kullanılarak farklı açılardan nesnelerin fotoğrafları gösterilmiş ve hangi figürün fotoğrafı çektiği sorulmuştur. Zihinsel rotasyon yeteneklerini değerlendirmek için Ghost Task (Frick, 2019; Frick et al., 2013; Frick & Pichelmann, 2023) görevi kullanılmış, döndürülmüş nesneler gösterilmiş ve bu nesnelerden birbiriyle eşleşenleri bulmaları istenmiştir. İlişkisel akıl yürütme yeteneklerini değerlendirmek için RMTS (Christie & Gentner, 2014) görevi kullanılmış, geometrik şekil çiftlerinden ilişkili olanı seçmeleri istenmiştir. Araştırma anaokullarında ve evlerde gerçekleştirilmiş, çalışma öncesinde ebeveynlerden yazılı onam alınmıştır. Görevler, sessiz bir odada araştırmacı eşliğinde uygulanmış, çocukların yanıtları videoya kaydedilmiş ve çalışmanın sonunda teşekkür edilerek küçük hediyeler verilmiştir.

Harita görevinin kodlaması, çocukların yazıya dökülmüş sözel yanıtlarına ve çizimlerine dayanılarak uygulanmıştır. Sözlü yanıtlar uzamsal, mekânsal ve eylem bilgileri olarak üç ana kategoride kodlanmıştır. Hedef, hedef olmayan ve rastgele hatırlanan kelimeler her kategori türü için hesaplanmıştır. Her harita ve her bilgi kategorisi için toplam puanlar oluşturulmuş ve hatırlanan hedef kelimenin maksimum hatırlanabilir kelime sayısına bölünmesiyle çocukların puanları hesaplanmıştır. Örneğin, “Eda evin önünde dururken bir kedi gördü” ifadesinde mekânsal sözcükler “önünde”, konum sözcükleri “ev” ve “kedi”, eylem sözcükleri “durmak” ve “görmek” olarak kodlanmıştır. Çocuğun hatırladığı kelimeler üzerinden uzamsal, mekânsal ve eylem puanları hesaplanmıştır. Harita görevindeki çizimler ise dört soruya göre kodlanmıştır: Tüm yer işaretleri doğru mu? Rota doğru mu? Rotanın sırası doğru mu? Girintili yollar belirtilmiş mi? Bu sorular 0-2 Likert tipi ölçekle yanıtlanmış ve ortalama puanlar hesaplanmıştır. Örneğin, bir çocuk için tüm sorulara kısmen doğru yanıtlar verilmişse toplam puan 0,5 olarak belirlenmiştir. PTT-C, Ghost Task ve RMTS için doğru cevaplar 1, yanlış cevaplar 0 olarak sayılmış ve deneme aşamasındaki puanları dahil edilmeden toplam puan hesaplanmıştır.

BÖLÜM 3

BULGULAR

Bu çalışma, içsel (perspektif alma, zihinsel döndürme, ilişkisel akıl yürütme) ve dışsal kaynakların (jest kullanımı ve perspektif) çocukların uzamsal performansı üzerindeki etkisini inceledi. Veriler, R 4.3.3 kullanılarak doğrusal karma etkili modelleme regresyon analizi ile analiz edildi. Çocukların sözel uzamsal, mekansal, eylem hatırlama ve çizim performansını değerlendirmek için dört model kullanıldı. Modellerde, harita görevinin açıklama koşulları (ön-yüz yalnızca konuşma, ön-yüz konuşma-jest, üst-arka konuşma-jest) ve çocukların PTT-C, Ghost Task ve RMTS puanları sabit etkiler olarak dahil edildi. Rastgele etkiler, katılımcılar ve görev nesneleri için kontrol edildi.

Uzamsal hatırlama performansı için model, sadece konuşma koşuluna kıyasla hem ön-yüz hem de üst arka perspektiflerden konuşma-jest kombinasyonu koşullarını karşılaştıran analizde ana etki ortaya koymuştur (ß = -0,33, SE = 0,13, p = 0,037). Yani, çocukların sözel uzamsal bilgi hatırlamaları, sadece konuşma koşuluna kıyasla konuşma-jest kombinasyonu koşullarında artmaktadır. Model ayrıca, PTT-C performansı ile ön-yüz ve üst-arka perspektiflerin multimodal koşullarını karşılaştıran karşılaştırmada anlamlı bir etkileşim ortaya koymuştur (ß = 0.29, SE = 0.14, p = 0.041). Yani, çocukların perspektif alma puanları arttığında, sözel uzamsal bilgi hatırlamaları jest-konuşma ön-yüz koşulunda (ß = 0.26, SE = 0.13, p = 0.05) jest-konuşma üst-aka koşuluna (ß = -0.04, SE = 0.13, p = 0.78) kıyasla önemli ölçüde artmaktadır. Diğer sabit etkilerin veya iki ve üç yönlü etkileşimlerin hiçbiri anlamlı değildi (ps > 0.05).

Mekansal hatırlama performansı için model, RMTS performansı ile açıklama koşulu arasında, sadece konuşma koşuluna kıyasla hem ön-yüz hem üst-arka perspektiflerden konuşma-jest kombinasyonu koşullarını karşılaştıran ikinci düzeyde anlamlı bir etkileşim ortaya koymuştur (ß = -0.19, SE = 0.09, p = 0.03). Yani, çocukların RMTS performansı arttığında, sözel mekansal bilgiyi hatırlamaları konuşma-jest kombinasyonu koşullarında [SGFF (ß = 0.24, SE = 0.10, p = 0.02; SGUB (ß = 0.17, SE = 0.10, p = 0.08)] sadece konuşma koşuluna (ß = 0.01, SE =

0.10, p = 0.88) kıyasla önemli ölçüde artmaktadır. Model aynı zamanda PTT-C, RMTS ve ikinci seviyedeki açıklama koşulu arasında üç yönlü bir etkileşim olduğunu ortaya koymuştur; bu etkileşim, sadece konuşma koşuluna kıyasla hem ön-yüz hem üst-arka perspektiflerden konuşma-jest kombinasyonu koşullarını karşılaştırmaktadır (ß = 0.32, SE = 0.13, p = 0.02). Bu bulgu, çocukların perspektif alma puanları ortalamada (ß = 0.24, SE = 0.10, p = 0.02) veya ortalamanın altında (ß = 0.49, SE = 0.21, p = 0.02) olduğunda, ön-yüz konuşma-jest koşulundaki sözel mekansal bilgi hatırlamaları RMTS performansının pozitif bir fonksiyonu olarak artmakta olmasıyla değerlendirilebilir. Diğer sabit etkilerin ya da iki ve üç yönlü etkileşimlerin hiçbiri konum modeli için anlamlı değildir (ps > 0.05).

Eylemsel hatırlama performansı için, model RMTS performansının marjinal olarak anlamlı bir ana etkisini ortaya koymuştur (ß = 0.13, SE = 0.06, p = 0.048). Çocukların RMTS puanları arttığında, sözel eylem bilgisi hatırlamaları da artmaktadır. Model ayrıca, RMTS performansı ve açıklama koşulu arasında, sadece konuşma koşullarına kıyasla hem ön-yüz hem üst-arka perspektiflerden konuşma-jest kombinasyonu koşullarını karşılaştıran ikinci düzeyde anlamlı bir etkileşim ortaya koymuştur (ß = -0.22, SE = 0.09, p = 0.01). Yani, çocukların RMTS performansı arttığında, sözel eylem bilgisi hatırlamaları, sadece konuşma içeren yönergelere kıyasla hem ön-yüz (ß = 0.19, SE = 0.09, p = 0.03) hem de üst-arka (ß = 0.23, SE = 0.09, p = 0.01) multimodal yönergeler aldıklarında artmaktadır. Model, PTT-C, RMTS ve açıklama koşulları arasında, öne ve arkaya bakan perspektiflerin multimodal koşullarını karşılaştıran ilk düzeyde üç yönlü bir etkileşim ortaya koymuştur (ß = -0.3, SE = 0.15, p = 0.043). Bu sonuçlar; çocukların perspektif alma puanı ortalamanın altında olduğunda, ilişkisel akıl yürütme performansının pozitif bir fonksiyonu olarak konuşma-jest ön yüz koşulunda yönlendirme almaktan faydalandıklarını (ß = 0.46, SE = 0.18, p = 0.01); ancak, perspektif alma puanı ortalamanın üzerinde olduğunda, konuşma-jest üst arka koşulunda yönlendirme aldıklarında ve yine ilişkisel akıl yürütme performansının pozitif bir fonksiyonu olarak daha fazla bilgi hatırladıklarını (ß = 0.26, SE = 0.13, p = 0.04) ortaya koymaktadır. Model aynı zamanda Ghost Task PTT-C ve açıklama koşulu arasında, sadece konuşma koşuluna kıyasla hem ön-yüz hem üst-arka perspektiflerden konuşma-jest kombinasyonu koşullarını karşılaştıran ikinci düzeyde başka bir üç

yönlü etkileşim ortaya çıkarmıştır (ß = -0.13, SE = 0.05, p = 0.01). Ancak, etkileşimin post-hoc analizleri anlamlı sonuçlar ortaya koymamıştır (ps > 0.05). Diğer sabit etkilerin veya iki ve üç yönlü etkileşimlerin hiçbiri eylem modeli için anlamlı değildi (ps > 0.05).

Çocukların çizim performansı için, sabit etkilerin veya iki ve üç yönlü etkileşimlerin hiçbiri anlamlı değildi (ps > 0.05).

BÖLÜM 4

TARTIŞMA

Sonuçlar, çocukların sözlü hatırlama performansının, multimodal dil içeren açıklamalar aldıklarında arttığını gösterdi. Mutlimodal dilin perspektifi ele alındığında, çocuklar, ön-yüz konuşma jest koşulundan, üst-arka konuşma jest koşuluna göre daha fazla yararlandı. Çocukların uzamsal yetenekleri arasında perspektif alma ve ilişkisel akıl yürütme yetenekleri, tüm sözlü hatırlama türlerinde hatırlama performanslarını yordamada en önemli beceriler olarak gözlemlendi. Son olarak, içsel (perspektif alma, ilişkisel akıl yürütme) ve dışsal (sunum perspektifi, multimodalite) kaynaklar arasındaki çeşitli etkileşimlerin, çocukların yalnızca sözel hatırlama davranışlarını yordadığı, davranışsal hatırlama performansıyla etkileşime girmediği bulundu

Multimodal anlatımlar

Multimodal anlatımlar, tüm hatırlama türlerinde çocukların performansını arttırmıştır. Bu bulgu, jestlerin uzamsal bilgi hatırlamayı nasıl kolaylaştırdığına dair mevcut literatürle uyumludur. Örneğin, Austin ve Sweller (2014) ve Kartalkanat ve Göksun (2020), jestlerin uzamsal ve hikâye anlatımı bağlamında hatırlamayı artırdığını bulmuşlardır. Bizim çalışmamız, jestlerin etkisini farklı perspektiflerden (ön-yüz, üst-arka) inceleyerek bu literatürü genişletmektedir. Sonuçlarımız, özellikle üst-arka perspektiften jestlerin, çocukların perspektif alma becerilerinin yüksek olduğu durumlarla daha fazla etkileşim halinde olduğunu göstermiştir.

Perspektif Alma ve İlişkisel Akıl Yürütme

Perspektif alma yetenekleri, çocukların uzamsal bilgiyi sözlü olarak hatırlamasıyla

ilişkilidir. Düşük perspektif alma becerisi daha yüksek ilişkisel akıl yürütme becerileri ile etkileşime girdiğinde, çocukların sözel hatırlama performansını konuşma-jest ön-yüz koşulunda artmaktadır. Bu, düşük perspektif alma becerisine sahip çocukların, multimodal dil girdisinden, ilişkisel akıl yürütme becerisinin olumlu bir işlevi olarak fayda sağlayabildiğini göstermektedir. Ayrıca, perspektif alma ve ilişkisel akıl yürütme yetenekleri arasındaki bu etkileşim, mekânsal ve eylemsel hatırlamada gözlemlenirken, uzamsal bilgi hatırlamada gözlemlenmemiştir.

Sınırlılıklar ve Öneriler

Çalışma, jest kavrayışının içsel ve dışsal kaynaklarının okul öncesi çocukların uzamsal performansları ile değerlendirilmesi açısından literatüre katkı sağlamaktadır. Bu çalışma, konuyu jest sunumu perspektifinden inceleyen ve üst-arka perspektifi dahil eden ilk çalışmadır. Ayrıca, çocukların ekranda sunulan görsel-uzamsal haritalar üzerindeki performanslarını değerlendirmek için çevrimiçi bir eğitim sunumu kullanan ilk çalışmadır. Bununla birlikte, görevimizdeki görsel-uzamsal haritaların 2 boyutlu haritalar olması ve çocukların haritaları deneyimleyememesi, somut haritalar, 3 boyutlu haritalar ve sanal gerçeklik cihazlarıyla kullanılan haritaların kullanıldığı çalışmalara kıyasla çalışmamızın sonuçlarını sınırlandırmıştır. İleride yapılacak çalışmalar, çocukların somut veya 3B görsel-uzamsal haritalar üzerindeki uzamsal performanslarını göz önünde bulundurarak ve görsel-uzamsal haritalar ile hatırlama türü arasındaki ilişkiyi göstermek için sözel ve davranışsal hatırlama performanslarını karşılaştırmaya odaklanabilirler.

Yol tarifi videoları sunulurken konuşmacının yüzüne yer verilmemiştir. Konuşma jestli üst-arka koşulunda konuşmacının yüzü görünmediği için açıklama koşullarını dengelemek adına konuşma jestli ön-arka ve sadece konuşma koşullarında da konuşmacının yüzünü dahil edilmemiştir. Literatür, dinleyicilerin konuşmacının görünür konuşmasından fayda sağladığını öne sürse de (Schubotz ve ark., 2020); konuşmacının jestinin, konuşmacının bakışları çevrildiğinde bile dinleyicinin anlamasını artırdığı gösterilmiştir (Holler ve ark., 2014). Dolayısıyla, konuşmacının görünmeyen yüzü sonuçlarımızı belli bir ölçüde sınırlamış olabilir. Sonuçlarımız sadece çocukların uzamsal performanslarıyla ilgili içsel ve dışsal jest anlama kaynaklarıyla sınırlıdır. Jest anlama ve uzamsal performanslar üzerine yapılan önceki çalışmaların aksine, bu çalışmada yetişkin bir örneklem çocuklarla

karşılaştırılmamıştı. Bununla birlikte, görsel-uzamsal görevlerde multimodal dil girdisinin anlaşılmasına katkıda bulunan gelişimsel faktörleri daha iyi anlamak için farklı yaş gruplarını dikkate almak önemlidir. Önceki çalışmalar (Austing & Sweller, 2014), çocukların görsel-uzamsal görevlerde yetişkinlere kıyasla multimodal dil yönlendirmelerinden daha fazla faydalandığını gösteren önemli bir yaş farkının altını çizmiştir. Gelecek çalışmalar, uzamsal performanslardaki farklılıkları daha iyi göstermek için çocuklar ve yetişkin örnekleri arasındaki iç ve dış kaynaklardaki varyasyonları da değerlendirebilir.

Son olarak, harita görevine ilişkin değerlendirmemiz sırasında, aktif bir konuşmacı olmadığı için çocuklar bir tablet ekranıyla pasif öğrenme gerçekleştirmiştir. Önceki araştırma bulguları, yetişkinlerin pasif öğrenmeden nasıl faydalanabileceğini göstermiştir (Qui vd., 2020) ve sonuçlarımız, çocukların da uzamsal navigasyon görevlerinde pasif öğrenme stratejilerinden faydalanabileceğini göstererek önceki bulguları desteklemektedir. Bununla birlikte, gelecek çalışmalar çocukların uzamsal navigasyon görevlerindeki performansını değerlendirmek için pasif ve aktif öğrenme stratejilerini karşılaştırabilir.

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