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Effects of Representational Gestures on Preschool Children's Story Comprehension and Word Learning

Elara Lutz[a] & Jan Lenhart[b]

[a] *University of Bamberg, Department of Psychology*
[b] *University of Bamberg, Department of Psychology, corresponding author, e-mail:* jan.lenhart@uni-bamberg.de, https://orcid.org/0000-0001-6235-7396

ABSTRACT: Gestures are in integral part of human communication and observing gestures during storytelling might increase recipients' learning and memory because they add visual information to speech. In the present study, we examined the effects of representational gestures on preschool children's story comprehension and word learning from a story. To do so, 89 three- to six-year-old German preschool children listened to a videotaped story either without gestures or with representational gestures. After the story presentation, story comprehension and receptive and expressive target-word tests were administered. Listening to a videotaped storytelling with gestures increased children's receptive and expressive target-word learning as well as their story comprehension significantly compared to the version without gestures. The effects did not depend on children's age. Including representational gestures during storytelling is a promising way for helping children to get a better grasp of spoken information and to acquire new words. Incorporating representational gestures into everyday storytelling or teaching routines offers a low-cost, low-effort method that can significantly enrich language input. Gestures might not only capture children's attention but also provide concrete visual scaffolding that helps making unfamiliar words and story elements more accessible and memorable.

Keywords: *gesture, storytelling, word learning, story comprehension*

Introduction

Spontaneous gesturing is an important part of everyday human communication, found across different cultures and ages (Goldin-Meadow, 1999). Gestures are also a naturally occurring part of many educational situations such as storytelling, shared reading, or classroom instruction (Barnes et al., 2025; Goldin-Meadow et al., 1999; Neugebauer et al., 2025; Oliveira & Barnes, 2019), which highlights the multimodal nature of many educational settings (Siegel, 2006). Gestures can occur on their own without speech, substituting for verbal communication, or they can be produced accompanying speech, where they can help to create the connection between words and meaning (Goldin-Meadow, 1999). Gestures can be classified into different categories and might serve different communicative functions (Hostetter, 2011; McNeill, 1992). Deictic gestures, also known as pointing gestures, are used to indicate objects or locations by pointing in the corresponding direction (e.g., pointing in the direction of the teddy, which a child is currently searching for). Representational gestures, which include iconic and metaphoric gestures, convey meaning relevant to co-occurring speech via form and motion[1]. Iconic gestures mimic the sensory characteristics of a referent and are particularly useful for expressing concepts in various semantic domains, such as actions or objects (e.g., flapping the arms to represent a bird flying). Metaphoric gestures, in contrast, employ physical movements to represent abstract concepts (e.g., a grasping or gripping motion with the hand to illustrate the concept of understanding). Beat gestures are rhythmic hand movements that accompany speech flow, often serving to emphasize particular aspects of spoken language without conveying semantic information (e.g., tapping with the hand or finger). Finally, interactive gestures are movements used to manage turn taking and other aspects of an interaction between multiple speakers.

It has been proposed that gestures represent embodied cognition (Hostetter & Alibali, 2008) and that they are inherently linked to speech, forming an integrated system of communication (McNeill, 1992; Overoye & Storm, 2019). Indeed, young children's spontaneous use of gestures and their verbal development are substantially correlated, being highly suggestive of common underlying mechanisms of development (Capone & McGregor, 2004; Goodwyn & Acredolo, 1998). In addition, the reliance on gestures for understanding the environment and learning emerges early in development. For instance, even one-year-old children understand that concurrently occurring communicative

[1] The term representational is used in different ways in the literature. In the present article, we follow Hostetter (2011) and Gámez et al. (2017) who use representational as a category that includes iconic and metaphoric gestures. Barnes et al. (2023) and Neugebauer et al. (2025) use iconic for culturally-shared, symbolic gestures with an agreed-upon meaning and representational for less-conventional pantomiming or movements that resemble a word's meaning.

signals (words and deictic gestures) co-refer to the same object, when both information are provided by the same source (Gliga & Csibra, 2009). And combining speech and gestures facilitates toddlers' language comprehension compared to speech only without gestural information (Morford & Goldin-Meadow, 1992). In preschoolers, a similar beneficial effect of gesture support on language comprehension has been demonstrated for complex but not for simple spoken information (McNeil et al., 2000).

Different mechanisms have been proposed to explain how gestures might benefit observers' learning (for overviews, see Hostetter, 2011; Lawson-Adams & Dickinson, 2021). One theory suggests that gestures that are semantically associated with the content of speech improve encoding (Woodall & Folger, 1981). By adding visual information to speech, gestures provide learners with more pathways for processing and retrieving information and might thus strengthen conceptual understanding and long-term retention (Hostetter & Alibali, 2008). Thus, with respect to word learning gestures might help to acquire a deeper and broader lexical entry (Perfetti, 2007). This approach aligns with the dual-coding theory (Paivio, 1986), which posits that combining visual and verbal information strengthens learning and memory. It also aligns with Baddeley's (2020) concept of working memory which posits that verbal information (via the phonological loop) and visual information (via the visuo-spatial sketchpad) can be processed simultaneously in working memory. According to Baddeley both types of information are integrated in the episodic buffer, resulting in better learning than by visual or auditive presentation alone *("modality effect"*, Sweller et al., 2019). Another theory suggests that gestures might help directing listeners' attention towards the verbal input and thereby increase word learning and comprehension (Barnes et al., 2023; Lenhart et al., 2020). Finally, gesturing might help speakers to produce more informative verbal descriptions (Kita, 2000). For example, Hostetter and colleagues (2007) could show that speakers use words that are more image-evoking when they gesture than when they do not gesture. Although this effect might help explaining positive effects of gestures during free speech (e.g., free storytelling), it cannot explain positive effects when the auditive information remains the same (e.g., reading aloud).

Accordingly, gestures may facilitate language comprehension and the learning of words by several nonmutually exclusive ways (Hostetter, 2011; Lawson-Adams & Dickinson, 2021). Although many studies have shown that gestures – particularly representational ones – have positive effects on comprehension, memory and learning across age groups (for meta-analyses, see Dargue et al., 2019; Hostetter, 2011), this facilitation and support might be particularly important for listeners who are less linguistically proficient and/or need more help to sustain and focus their attention – such as young children (Barnes et al., 2023; Hostetter, 2011), second language learners (Lewis & Kirkhart, 2020; Macedonia et al., 2011), or students with a specific language impairment (Frey & Lüke, 2023; Vogt &

Kauschke, 2017). Accordingly, in the present study we examined effects of observing representational gestures on preschool children's story comprehension and acquisition of novel words from a story in a well-controlled experimental design. We also examined whether effects of observing gestures on word learning and story comprehension depended on preschool children's age.

Gestures and Preschoolers' Story Comprehension

As proposed observing gestures might increase preschool children's story comprehension via several different nonmutually exclusive mechanisms. Supporting this idea, several experimental studies have demonstrated that preschoolers' comprehension of verbal information benefits from accompanying gestures (e.g., Austin & Sweller, 2014, 2017; Dargue & Sweller, 2018, 2020; Kartalkanat & Göksun, 2020; Macoun & Sweller, 2016; McNeil et al., 2000; Pine et al., 2010). For instance, Austin and Sweller (2014) presented participants a small-scale spatial array constructed from Lego materials in which a Lego character was described to take a certain route. They found that providing children with a mix of deictic, iconic, and metaphoric gestures during the verbal description improved children's recall of the locations the Lego character passed (for similar findings, see Austin & Sweller, 2017). Using a more typical story setting, Dargue and Sweller (2018) could show that presenting iconic gestures that matched the spoken content of a story (but not those that contradicted it) improved children's narrative comprehension, which was measured by a mix of open-ended and forced-choice questions. Moreover, a study conducted by Macoun and Sweller (2016) indicates that this beneficial effect seems not to generalize to the comprehension of story aspects not targeted with gestures.

This experimental evidence of positive effects of observing (and producing) gestures is supplemented by correlational evidence that found positive correlations between adults' gesturing, children's use of gestures, and children's comprehension (e.g., Bernstein et al., 2024; Lenhart et al., 2020; Schmidt et al., 2024). Lenhart et al. (2020), for example, compared reading aloud to free storytelling and found that narrators' gesturing during story presentation was positively related to preschool children's story comprehension. Bernstein et al. (2024) compared a drama-based instruction, which includes gestures and movements, to traditional book reading. They found that drama-based instruction increased children's embodied behaviours including gesture during story retelling and that displaying more embodied behaviours was associated with recalling more story elements during a free retell task.

Gestures and Word Learning form Stories

The theoretical underpinnings for effects of gestures on word learning from stories mirrors those for effects on story comprehension. Turning to empirical evidence, studies could demonstrate beneficial effects of gestures on novel word learning (e.g., Frey & Lüke, 2023; Heidari, 2015; Vogt & Kauschke, 2017). Heidari (2015), for example, asked a teacher to teach three- to six-year-old Iranian children novel words in one class without using gestures and in the other class to do so while using gestures. He found that children in the gesture condition outperformed the children in the no-gesture condition on vocabulary learning. In a published study, Frey and Lüke (2023) trained teachers to use iconic gestures during mathematics lessons in Grade 1 and 2 in primary school. They found that students in classrooms in which the teachers were trained to use gestures improved more regarding their expressive (picture naming task) but not their receptive knowledge (picture selection task) of specific target words. Although the designs used in Heidari's (2015) and Frey and Lüke's (2023) studies profit from high ecological validity, in naturalistic settings the control is less strict than in experimental settings, which might negatively influence internal validity.

The quasi-experimental evidence of positive effects of observing (and producing) gestures is supplemented by correlational evidence that found positive correlations between adults' gesturing, children's use of gestures, and children's word learning (e.g., Barnes et al., 2023; Gámez et al., 2017; Lenhart et al., 2020). Gámez et al. (2017), for example, found that teachers' use of representational gestures in classroom, which included story sessions, resulted in gains in expressive vocabulary for Spanish-speaking English learners and their English-only peers, who were mostly from low-income and ethnic-minority backgrounds. Moreover, Barnes et al. (2023) examined teachers' gesturing in Head Start prekindergarten classrooms. They found that children in classrooms where teachers used more gestures had higher end-of-year receptive vocabulary scores than those in classrooms where teachers used fewer gestures. Importantly, Barnes et al. (2023) controlled for several potentially confounding variables, such as the classrooms' linguistic input, children's prior receptive vocabulary, and their nonverbal intelligence.

Age as a Moderator Variable

It has been proposed that gesturing might be particularly important for listeners who are less linguistically proficient and/or need more help to sustain and focus their attention – such as young children (Barnes et al., 2023; Hostetter, 2011), second language learners (Lewis & Kirkhart, 2020; Macedonia et al., 2011), or students with a specific language impairment (Frey & Lüke, 2023; Vogt & Kauschke, 2017).

Concerning age as a moderator, the two relevant meta-analyses (Dargue et al., 2019; Hostetter, 2011) reported different results. While Hostetter (2011) found that beneficial effects of gestures were more pronounced in studies with children (d = 0.84) than in studies with adults (d = 0.51), this difference between studies was considerably smaller and non-significant in the more recent meta-analysis conducted by Dargue et al. (2019) (preschool children: d = 0.73, primary schoolchildren: d = 0.58; adolescents: d = 0.68; adults: d = 0.57). However, it is difficult to interpret these effects because studies conducted with different age groups differed also concerning other aspects (e.g., types of gestures, complexity, etc.) and there was no fine-grained differentiation within these broad age groups. Importantly, McNeil et al. (2000) directly compared the beneficial effects of gestures on preschool children's (aged 46 to 57 months) and kindergarten children's (aged 59 to 72 months) comprehension of spoken language. They found that gestures that supported complex spoken information increased preschool children's but not kindergarten children's understanding. In contrast, gestures that supported simple spoken information had – irrespective of the age group – no effects on children's comprehension.

There is also evidence from studies focusing on linguistic proficiency that less proficient learners might particularly profit from gestures. Silverman and Crandell (2010), for example, observed teachers' behaviour during language arts blocks and assessed the receptive vocabulary knowledge of the children (aged 4 to 6 years) at the beginning and end of the year. They found that supplementing read alouds through acting or illustrating vocabulary was positively associated with children's general receptive vocabulary at the end of the year, when scores at the beginning of the year and other types of supporting behaviour such as definitions or contextualization were included as covariates. This effect was even more pronounced in children with lower vocabulary pre-test scores than in their already more proficient peers. Moreover, in a well-controlled experimental design, Rowe et al. (2013) taught monolingual and bilingual preschool children two new words for objects in each of three within-subjects conditions: just the word alone, the word with a matching picture, or the word with a matching iconic gesture. Then they asked children to provide the English word for each of the novel words (translation task) and to select the correct object out of three presented objects (comprehension task). While children could equally well name the English word in each of the conditions, story comprehension differed for bilingual children depending on their language ability, with children having low English language ability profiting most strongly from gestures during novel word learning. Similar findings were reported in a study conducted by Sueyoshi and Hardison (2005) on adult second-language learners. Those who had low skills in their second language profited most from gestures during a listening comprehension task in the second language.

For interpreting this aptitude-treatment interaction, Rowe et al. (2013) draw on the complexity hypothesis proposed by McNeil et al. (2000), which claims that providing additional information to speech in the form of gestures is beneficial when the task is complex for the learner. The same may be argued for younger children, whose cognitive and verbal skills are not yet fully developed (for similar arguments, see Barnes et al., 2023; Hostetter, 2011).

The Current Study

The current study built on theoretical accounts proposing beneficial effects of gestures due to the semantic information they provide (Lawson-Adams & Dickinson, 2021; Woodall & Folger, 1981) as well as their attention guiding function (Lawson-Adams & Dickinson, 2021; Lenhart et al., 2020). Indeed, a growing body of research shows beneficial effects of gestures on speech comprehension and learning in children, adolescents, and adults (for meta-analyses, see Dargue et al., 2019; Hostetter, 2011). Preschool children seem to profit from gestures regarding their comprehension of spatial directions (Austin & Sweller, 2014, 2017) and of story contents (Dargue & Sweller, 2018; Macoun & Sweller, 2016), as well as their vocabulary learning (e.g., Frey & Lüke, 2023; Heidari, 2015; Rowe et al., 2013). However, it is less clear if gestures benefit receptive and expressive vocabulary learning and story comprehension to a similar degree and if beneficial effects of gestures depend on learner characteristics such as age. Indeed, such an aptitude-treatment interaction might occur, with gestures being supportive when the complexity of the task exceeds the competences of the learner (McNeil et al., 2000; also see Barnes et al., 2023).

Accordingly, in the present study we examined the effects of representational gestures on preschool children's story comprehension as well as their receptive and expressive word learning from stories in an experimental design. Representational gestures were selected for the present study, given their ability to visually represent concepts. Representational gestures resemble the actions or objects they represent, adding non-verbal semantic information to speech, which might be used for word learning and story comprehension (McNeill, 1992; Goldin-Meadow, 1999). Moreover, following the suggestion that effects of gestures might also depend on leaners' characteristics such as age, we explored if children's age might moderate gesture effects on story comprehension and word learning. Following the complexity hypothesis (McNeil et al., 2000) and previous findings on age effects (McNeil et al., 2000) as well as on language proficiency (Rowe et al., 2013; Silverman & Crandell, 2010), we assumed that in particular younger children might profit from the additional visual aid provided by gestures during storytelling. Accordingly, we tested the following hypotheses:

Hypothesis 1: Observing representational gestures during storytelling enhances preschool children's productive vocabulary learning compared to storytelling without gestures.

Hypothesis 2: Observing representational gestures during storytelling enhances preschool children's receptive vocabulary learning compared to storytelling without gestures.

Hypothesis 3: Observing representational gestures during storytelling enhances preschool children's story comprehension compared to storytelling without gestures.

Hypothesis 4: The beneficial effects of observing representational gestures are moderated by children's age, with younger preschool children profiting more from gesture-supported storytelling than older preschool children.

Method

Participants

A total of 89 three- to six-year-old preschool children (*M* = 58.03 months, *SD* = 12.30 months, ranging from 36 months to 83 months) from two kindergartens in Germany participated in the study. Children were only permitted to participate if parents had provided written consent. Of the sample, 53% were female, and 96% were raised with German as their native language, with 94% of mothers and 93% of fathers being German native speakers. All children had at least one parent with a formal educational qualification. Among parents, 34% of mothers and 30% of fathers held a university degree and 10% of mothers and 12% of fathers had obtained a higher education entrance qualification (Abitur) as their highest educational level, which is comparable to the German population (Statistisches Bundesamt, 2020).

Based on a previous meta-analysis on effects of gestures on comprehension (Dargue et al., 2019; *d* = 0.73 for preschool children) we conducted a power analysis with G*Power (Faul et al., 2007) for an independent groups t-test (one-tailed; $\alpha = .05$, $1-\beta = .80$). The required sample size was 48, which was surpassed in the present study. An additional sensitivity analysis indicated that the present study was sufficiently powered to detect a medium effect size (*d* = 0.53).

Design and Procedure

To investigate the effects of representational gestures, a between-subjects experiment with two conditions was conducted. In the experimental condition, nine selected target words (seven nouns and two verbs) were illustrated with representational gestures

during storytelling, while in the control condition, the story was narrated without gestures. The dependent variables were productive and receptive target vocabulary and story comprehension. Children were randomly assigned to one of the two conditions.

Prior to the start of the study, a questionnaire was distributed to the parents including items on demographic variables and the children's home literacy environment. The experimental part of the study included the story presentation, which consisted of a prerecorded video (duration approximately five minutes) to ensure that there were no differences in presentation between the subjects of the same condition, and an assessment of receptive and productive vocabulary and story comprehension following the story presentation. The study had a duration of approximately 20 minutes, was conducted in a one-to-one session with each child and took place in a separate room provided by the kindergarten, in which only the child and the experimenter were present during the study. After completing the session, all children received a glass bead as a thank-you gift.

Stimuli

Experimental Story

Two different five-minute videos were recorded as stimulus material, each featuring the experimenter narrating the story for the two experimental conditions. The story *Der Tiger, der Brahmane und der Schakal* (English: *The tiger, the Brahmin and the jackal*; Jacobs, 2018), was selected after consultation with a daycare educator and was adapted and shortened to ensure age-appropriateness for the target group. We also checked that sufficient context information was provided for the children to infer the meanings of the target words.

The videos for the control and experimental groups differed only in the presentation style of the story. In the control condition video, the story was narrated without using gestures. In the experimental condition video, each target word was accompanied by an appropriate representational gesture when the word was mentioned for the first time. For example, the word buffalo was supported by the narrator placing her fists on either side of her head, moving them upward to suggest horns (for a description of the gestures, see Table 1). To minimize distractions, no objects were visible in the videos.

TABLE 1 Target words and gestures

Target Word	Description of Gestures
Schakal (jackal)	Hands in front of the upper body, palms down, wiggle them up and down
Klauen (claws)	Move hands forward and curl fingers
Detail (detail)	Raise hand to head height and press thumb and index finger together
Abendmahl (supper)	Bring hand (with an imaginary fork) to mouth
Luke (hatch)	Hold left hand, palm facing up, at chest level, and clap with right hand
Büffel (buffalo)	Place fists on either side of the head and form horns by moving them upward
Zwinger (kennel)	Spread fingers apart, bend them, and hold hands together in front of the torso (fingertips touching)
Pumpen (to pump)	Hold fists side by side at chest level and move them up and down
Schaudern (to shudder)	Cross arms in front of the body and wiggle them back and forth

Target and Control Words

The target vocabulary consisted of nine words, including seven nouns (German: Schakal, Klauen, Detail, Abendmahl, Büffel, Zwinger, Luke; English translation: jackal, claws, detail, supper, buffalo, kennel, hatch) and two verbs (German: pumpen, schaudern; English translation: to pump, to shudder) (see Table 1). Nine words were chosen as targets so that, on the one hand, a variety of gestures could be used, but on the other hand, the children would not be overwhelmed by too many gestures during story presentation. To ensure the unfamiliarity of these target words, five of the original words from the story were replaced with synonyms. These nine target words were expected to be unfamiliar to preschool children based on their low frequency in the ChildLex database (Schroeder et al., 2015). The meaning of all target words could be inferred from the contextual information contained in the text.

In addition, three words that also appeared in the story were used as control items, which included two nouns (German: Baum, Straße; English translation: tree, street) and one verb (German: weinen; English translation: to cry). These words were assumed familiar to the children based on their high frequency of occurrence in the ChildLex database (Schroeder et al., 2015). The control items were included for two reasons. We wanted to check whether the children understood the instructions of the target-word tasks. In addition, the control words were used to motivate the children because interspersing easy well-known control words within the unknown target words provided all children with experiences of success. These words were not accompanied by gestures in any of the conditions.

Variables

Demographics and Home Literacy Environment

The parents completed a questionnaire regarding demographic variables and the home literacy environment of the children, including questions on their own and their children's country of birth and mother tongue, the child's date of birth, the number of (children's) books, the frequency of shared reading, and their highest educational qualification.

Productive Target Vocabulary

To assess productive target-word acquisition, the experimenter presented the words orally to each child and the child was then required to explain the meaning of the word, which is a standard procedure in shared-book-reading research (e.g., Blewitt et al., 2009; Lenhart et al., 2020; Suggate et al., 2021). The full score of 1 point was awarded when the word was explained correctly (e.g., the explanation for "buffalo" received 1 point if children said *"an animal with horns"*). A score of 0.5 points was given for partially correct responses (e.g., naming superordinates, properties, or associated concepts, e.g., the explanation for "buffalo" received 0.5 points if children said *"an animal"*). No points were awarded for no response or an incorrect response. The sum of the items was calculated, resulting in scores ranging from 0 to 9. The three control items were interspersed in the nine target words. The scale showed an acceptable internal consistency (McDonald's ω = .773). To ensure the objectivity of ratings, a second rater independently provided an additional rating. The intraclass correlation was ICC(3,1) = .970 with a 95% confidence interval [.954, .986]. These values fell within the excellent range (Koo & Li, 2016). All disagreements were then discussed, and a final consensus rating was made, which served as the basis for data analysis. The three control items were interspersed in the nine target words.

Receptive Target Vocabulary

To measure the receptive target-word acquisition, a test oriented in design at the Peabody Picture Vocabulary Test-4 (PPVT-4; Dunn & Dunn, 2007) and standard word acquisition methods from studies on shared book reading (e.g., Blewitt et al., 2009; Lenhart et al., 2020; Suggate et al., 2021) was constructed using the same nine target-words. For the receptive target vocabulary test, picture cards were created by the first author. For each item, four picture cards were presented, one of which depicted the target word. Children were presented with the target word verbally and then asked to point to the corresponding image. The sum of the items was calculated, resulting in scores ranging from 0 to 9. The three control items were interspersed in the nine target words. The scale showed an acceptable internal consistency (McDonald's ω = .592).

Story Comprehension

The story comprehension test consisted of five open-ended questions, presented sequentially. For each response, the values of 0, 0.5, or 1 point were assigned (for a similar approach, see Lenhart et al., 2020). No points were awarded if no response or an incorrect response was provided. An incomplete or partially correct response was rated with 0.5 points (e.g., children were asked to name all the animals/objects the Brahmin asks for help. They received 0.5 points if children named only some of them). A full point was awarded when all relevant information was included in the response (e.g., children named all of the Brahmin's interlocutors). The sum of the items was calculated, resulting in scores ranging from 0 to 5. The scale showed an acceptable internal consistency (McDonald's ω = .770). A second independent rater coded the responses, after which a consensus rating was established for further analysis. The intraclass correlation was ICC(3,1) = .975 with a 95% confidence interval [.963, .984]. These values fell within the excellent range (Koo & Li, 2016).

Data Preparation and Analysis

Data preparation was conducted with Excel, and data analysis was performed with JASP (Version 0.19.1; JASP Team, 2024). The significance level was set at $p < .05$, with directed hypotheses being tested one-tailed. As the Q-Q plots indicated no meaningful deviations of the residuals from normality, independent samples t-tests were conducted to analyze the effect of gestures on the productive and receptive target vocabulary and text comprehension. Additionally, multiple linear regression analyses were performed to examine the moderating effect of participants' age. For the multiple linear regression analyses, age was mean centered prior to the analyses.

Results

Preliminary Analyses

To check if random assignment of the children to the experimental conditions had worked properly, we compared both groups regarding the demographic and home-literacy variables that we had collected prior to the experiment via parent questionnaire. We found no statistically significant differences between children in the two groups in any of these variables (children's age: $p = .377$; children's gender: $p = .930$; mother tongue child: $p = .658$; mother tongue mother: $p = .999$; mother tongue father: $p = .237$; maternal education: $p = .510$; paternal education: $p = .646$; number of books at home: $p = .388$; number of children's books at home: $p = .328$; frequency of shared reading/storytelling at home: $p = .677$).

Moreover, to verify that children understood the instructions of the target-vocabulary tasks and were motivated to provide an appropriate answer, we examined their performance regarding the three control words that were interspersed within both target-word tests. Descriptive statistics indicate almost perfect performance in both conditions (productive control words: control group: M = 2.78, SD = 0.37; experimental group: M = 2.78, SD = 0.33; receptive control words: control group: M = 2.95, SD = 0.21; experimental group: M = 2.98, SD = 0.15). There were no statistically significant differences between the two experimental conditions concerning productive control words, $t(87) = 0.05$, $p = .962$, $d = 0.01$ with 95%-CI [-0.41; 0.43], and receptive control words, $t(87) = 0.64$, $p = .523$, $d = 0.14$, with 95%-CI [-0.28; 0.55]. As the Q-Q plots indicated deviations from normality, we also conducted Mann-Whitney U tests, which showed a similar pattern of results for productive control words, U = 966, $p = .823$, $r = .02$, with 95%-CI [-.22; .26], and receptive control words: U = 528, $p = .528$, $r = -.03$, with 95%-CI [-.26; .21].

Table 2 provides an overview of the descriptive statistics for all dependent variables investigated in the present study – shown separately for the control (verbal only) and experimental group (verbal + gestures). There were no floor or ceiling effects observable in the dependent variables.

TABLE 2 Descriptive Statistics for Vocabulary and Comprehension Measures

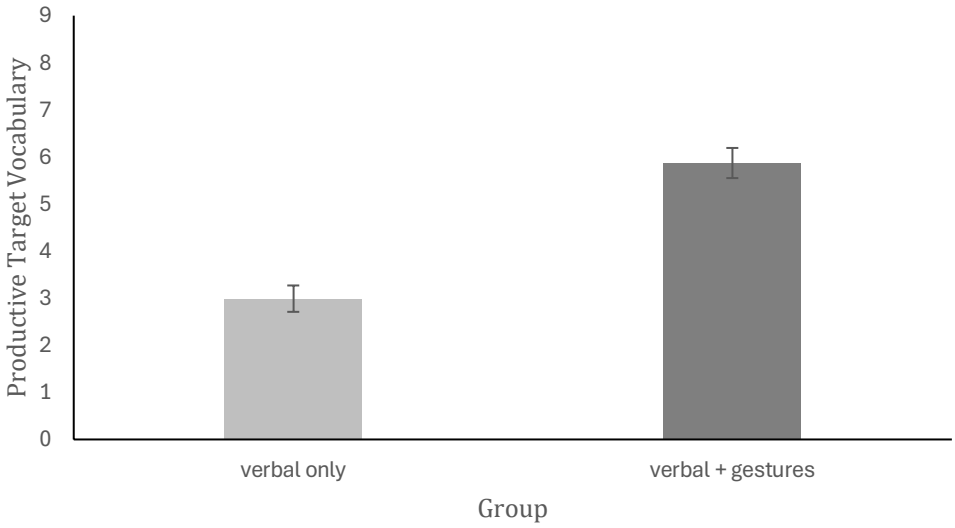
	Productive Target Vocabulary		Receptive Target Vocabulary		Story Comprehension	
	Verbal only	Verbal + Gestures	Verbal only	Verbal + Gestures	Verbal only	Verbal + Gestures
n	43	46	43	46	43	46
M	2.99	5.87	5.49	7.24	2.07	3.70
SD	1.82	2.14	1.75	1.58	1.30	1.36
Min	0.00	1.50	2.00	4.00	0.00	0.00
Max	7.00	9.00	9.00	9.00	5.00	5.00

Note. Scores range from 0 to 9 for vocabulary tasks and 0 to 5 for text comprehension.

Effect of Gestures on Productive Target Vocabulary

An independent samples t-test revealed a significant difference between the experimental group (verbal + gestures) and the control group (verbal only), $t(87) = 6.81$, $p < .001$, $d = 1.44$ with 95%-CI [1.05; ∞]. The experimental group achieved higher scores (M = 5.87) compared to the control group (M = 2.99) (see Figure 1). This result supports Hypothesis

1, indicating that observing representational gestures during storytelling significantly increased preschool children's productive target vocabulary learning form stories.

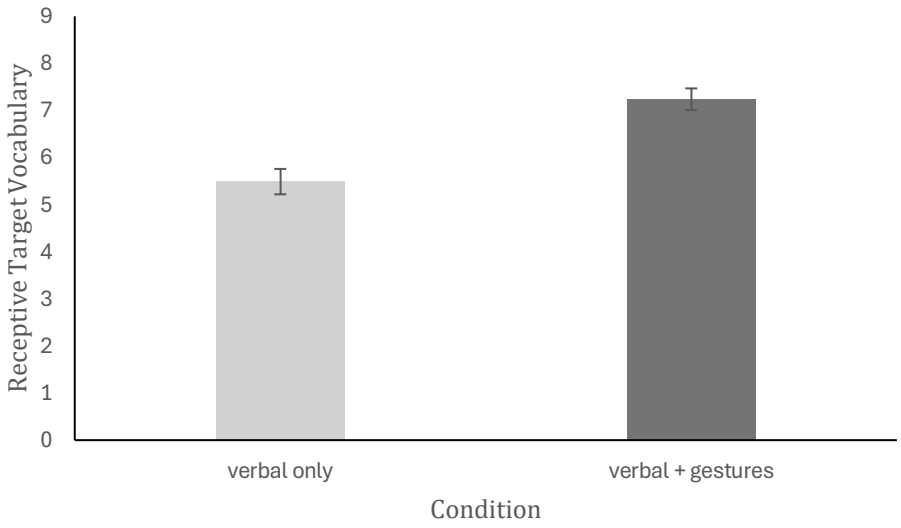


Note. Error bars represent the standard error (SE).

FIGURE 1 Effect of Gestures on Productive Target Vocabulary

Effect of Gestures on Receptive Target Vocabulary

An independent samples t-test revealed again a significant difference between the experimental group (verbal + gestures) and the control group (verbal only), $t(87) = 4.96$, $p < .001$, $d = 1.05$ with 95%-CI [0.68; ∞]. The experimental group scored significantly higher (M = 7.24) than the control group ($M = 5.49$) (see Figure 2). This result supports Hypothesis 2, showing that the presence of representational gestures during storytelling increased preschool children's receptive vocabulary learning from stories.

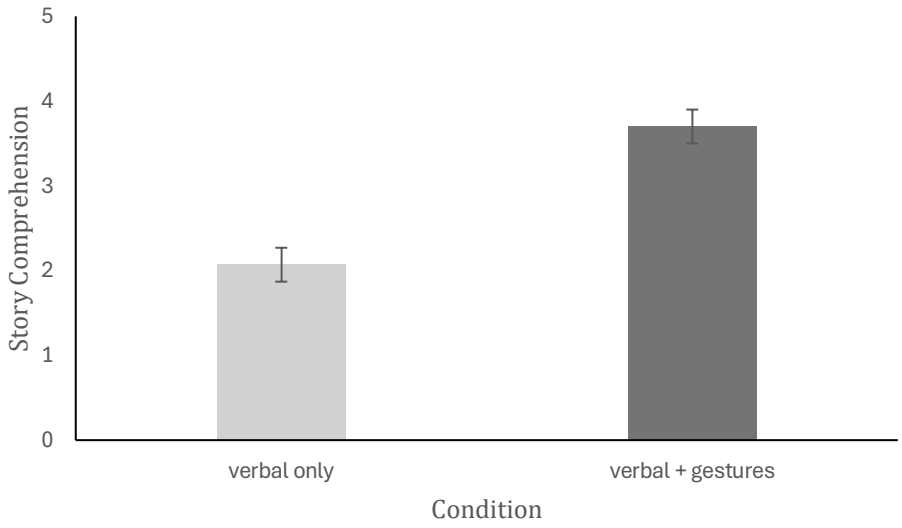


Note. Error bars represent the standard error (SE).

FIGURE 2 Effect of Gestures on Receptive Target Vocabulary

Effect of Gestures on Story Comprehension

An independent samples t-test was computed to test whether observing gestures during storytelling enhanced preschool children's story comprehension. Children in the experimental group had significantly higher scores on the story comprehension test (M = 3.70) than children who viewed the video without gestures (M = 2.07), $t(87) = 5.75$, $p < .001$, $d = 1.22$ with 95%-CI [0.84; ∞] (see Figure 3). This result supports Hypothesis 3, demonstrating that observing representational gestures during storytelling led to a significant improvement in preschool children's story comprehension.



Note. Error bars represent the standard error (SE).

FIGURE 3 Effect of Gestures on Text Comprehension

Age as a Moderator Variable

Multiple linear regression analyses were conducted to examine whether the effects of representational gestures on productive and receptive vocabulary and on story comprehension were moderated by participants' age. Age was included as a covariate alongside the condition (gestures vs. no gestures) and the interaction term between age and condition. The analyses revealed that the interaction effect of age and condition was not significant for any of the dependent variables (productive vocabulary: $B = 0.000$, $p = .999$; receptive vocabulary: $B = 0.025$, $p = .351$; story comprehension: $B = 0.000$, $p = .987$). Thus, the positive effect of observing gestures during storytelling did not vary depending on the child's age, suggesting that representational gestures can be an equally effective tool for language enhancement for both younger and older preschool children.

Discussion

Summary and Interpretation of the Results

The present study investigated the effects of representational gestures during storytelling on preschool children's productive and receptive vocabulary as well as on their story comprehension. Additionally, we examined whether these effects were moderated by children's age. The results of our study provide strong support for a positive effect of gestures. Children who were exposed to storytelling enriched with representational

gestures showed significantly higher scores in productive vocabulary, receptive vocabulary, and story comprehension compared to children who listened to the story without gestures. All effects were large, suggesting that the use of gestures meaningfully enhanced both word learning and comprehension. Interestingly, the interaction between age and gesture condition was not significant in any of the analyses, indicating that the beneficial effects of gestures were similar across the entire age range of our preschool sample.

These findings are in line with previous (quasi-)experimental research that has shown gestures to support speech comprehension (e.g., Austin & Sweller, 2014, 2017; Dargue & Sweller, 2018) and word learning (e.g., Frey & Lüke, 2023; Heidari, 2015) in preschool children. The findings also agree with many correlational studies finding positive associations between gestures usage and children's word learning (e.g., Barnes et al., 2023; Gámez et al., 2017; Lenhart et al., 2020) and language comprehension (e.g., Bernstein et al., 2024; Lenhart et al., 2020; Schmidt et al., 2024) during shared reading, storytelling, or other classroom practices. Our findings also agree with theoretical assumptions which assume a beneficial effect of gestures by several nonmutually exclusive ways (for overviews, see Hostetter, 2011; Lawson-Adams & Dickinson, 2021). Gesture might either provide additional information that helps to strengthen conceptual understanding and long-term retention (Hostetter & Alibali, 2008) and to acquire a deeper and broader lexical entry for words (Perfetti, 2007). This aligns with information processing theories, such as the dual-coding theory (Paivio, 1986) or Baddeley's concept of working memory with independent systems for verbal and visual input (Baddeley, 2020), which propose that combining verbal and visual information strengthens memory and learning. Of course, it is also likely that gesturing guided attention to specific words and aspects of the story and might thereby have had beneficial effects on word learning and story comprehension (Barnes et al., 2023; Lenhart et al., 2020). In the present study, it is not possible to disentangle those effects and probably both mechanisms co-occur in many learning situations.

Although children passively observed gestures without producing them themselves in the present study, it is also possible that observing gestures might have activated motoric representations associated with the words as proposed by accounts of embodied cognition (Hostetter & Alibali, 2008). Previous research suggests that it might be highly supportive for learning when learners actively perform gestures (Dargue & Sweller, 2019), thereby engaging sensorimotor processes more directly than by simply observing gestures (Hostetter & Alibali, 2008).

Lastly, we found no evidence for the hypothesis regarding a potential moderator effect of children's age. Though some theories have proposed that less advanced (e.g., Frey & Lüke,

2023; McNeil et al., 2000) or younger learners (e.g., Barnes et al., 2023; Hostetter, 2011) might particularly benefit from including gestures and earlier studies found that effects of observing gestures varies with learner characteristics, such as language proficiency (e.g., Rowe et al., 2013; Silverman & Crandell, 2010; Sueyoshi & Hardison, 2005) or age (McNeil et al., 2000), our findings indicate that representational gestures were similarly effective across the preschool years. This suggests that, within this age window, gesture-supported input can reliably enhance both word learning from stories and story comprehension independent of children's age. Although, in general, language and cognitive development are substantially related to children's age, they are by no means identical with age. Therefore, it is possibly that linguistic (e.g., language comprehension, vocabulary) or cognitive competencies (e.g., attention, executive functions) and not age per se moderate the effects of observing gestures on comprehension and learning.

Limitations and Directions for Future Research

Despite these promising results, several limitations should be considered. First, the study was conducted in only two kindergartens in Germany, which may limit the generalizability of the findings to other cultural or linguistic contexts. Second, the intervention involved only a single storytelling session that was followed by an immediate post-test. Thus, we cannot draw conclusions about the long-term effects of gestures on word learning or the retention of story content. Third, the study was limited to a small number of selected target words (consisting mostly of nouns) within a single story that was presented via screen and to a limited set of comprehension questions. This diminishes the ecological validity of the present study and its potential to generalize to more complex, naturalistic learning environments as well as to other stories and words. Finally, using age as a moderator variable to test the complexity hypothesis (McNeil et al., 2000; Rowe et al., 2013) might have been problematic due to the vast competence differences between same-aged children. Instead, indicators of children's cognitive (e.g., attention, executive functions) and language development (e.g., language comprehension, vocabulary) might be better suited to examine the complexity hypothesis. Thus, future studies might include follow-up measurement points, use a broader range of stories, more comprehension questions and target words, and might use a more naturalistic storytelling setting.

Conclusion

The present findings offer valuable practical implications for early childhood education practitioners in their everyday communication with children and for the design of language interventions. Representational gestures, through their vivid and visually grounded representations, can serve as powerful tools to enhance children's learning

experiences. For educators in preschool settings, incorporating representational gestures into everyday storytelling or teaching routines offers a low-cost, low-effort method that can significantly enrich language input. Gestures might not only capture children's attention but also provide concrete visual scaffolding that helps making unfamiliar words and abstract story elements more accessible and memorable. Importantly, these strategies are not limited to professional contexts. Parents and other caregivers can also make use of representational gestures during shared book reading or everyday conversations. By naturally integrating gestures into their interactions with children, adults can create a supportive, interactive environment that fosters language growth in a natural and enjoyable way.

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