# **10** VISUAL LANGUAGE & VISUAL LEARNING (VL2) LEARNING FROM SCIENCE: RESEARCH BRIEF

# **DIFFERENT WAYS OF THINKING:** THE IMPORTANCE OF GESTURE **IN CHILD DEVELOPMENT**



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# **KEY FINDINGS**

- Gesture communicates information not contained in language, for both deaf and hearing individuals.
- Gesture accompanies sign language, yet it is distinct from sign language.
- Gesture aids thinking and learning, particularly for math and science.
- Gestures often precede or accompany important milestones in spoken and sign language development.
- Gesture can communicate and impact readiness to learn.
- Gesture plays a role in the cognitive and social development of children, deaf and hearing alike.

# Different Ways of Thinking: The Importance of Gesture in Child Development

So-One Hwang, Ph.D., Melissa Herzig, Ed.D., & Carol Padden, Ph.D.

#### What is Gesture?

esture is found through the lifespan, from childhood to adulthood. It is also found across cultures.<sup>1</sup> For hearing individuals, gesture refers to the natural movement of the hands used with speech.

Why do people gesture as they speak? When gestures accompany speech, they can be used as an aid for communication, such as when it is necessary to describe what something looks like, for example, how wide or how tall it is. But gesture also plays an important role in thinking and learning.<sup>2</sup>

For hearing individuals using speech, gestures provide a way of creating visual imagery while talking, but we have learned that gesture is not limited to just this purpose. When talking on the phone, hearing people gesture even though the other person can only hear the voice.<sup>3</sup> Individuals who are blind since birth use gestures during conversations.<sup>4</sup>

From these examples, we have learned that gesture does more than just communicate. It can help with thinking and problem solving. If speakers are prevented from gesturing (such as holding their hands under the table), their speech fluency can decline.<sup>5</sup> On the whole, gesture and language are part of an integrated system of communication and provides us with a window into how humans think.<sup>6</sup>

A growing body of research has shown that gestures play a role in helping hearing students acquire concepts in math and science. Now there is new research showing that gesture may predict learning among deaf signing students as well, leading to new ways of understanding the benefits of gesture for both deaf and hearing children.

#### How is Gesture Different From Sign Language?

Humans are born with the ability to recognize linguistic input, whether it is spoken or signed, and it seems they also can distinguish language from gesture.

Researchers tested young infants (6 months old) who were shown videos of narratives in signs or pantomime gestures.<sup>7</sup> They found that young infants prefer to look at the signing video. With exposure to sign language, this pattern persists through 10 months of age, then declines for older infants who are not exposed to sign language. This study suggests that newborns have an ability to recognize unique properties of language that are different from gestures, a jump-start for learning language.

Although there is still debate over what counts as sign or gesture,<sup>8,9</sup> there is growing agreement that deaf signers also gesture while signing.<sup>10, 11, 12</sup> Gesture is distinguished from speech by its ability to show information through imagery and finer ("gradient") detail. Speech or signing provide information using words or signs in more absolute ("categorical") terms.

In the same way that hearing people talk and gesture at the same time (called "co-speech gesture"), we are learning that signers can sign and produce gestures together in order to convey unified meaning. Some gestures are easy to recognize in signers because they look like the gestures used by hearing individuals who do not sign. Other gestures may be harder to recognize because they are blended almost seamlessly with signs.

#### The Role of Gesture in Cognitive and Social Development

Children are naturally drawn to objects and events around them, sparking exploration and interaction with others. Before being able to name something, a gesture as simple as pointing can serve as a stepping-stone to using spoken words. Children engage in games with each other and with adults, which some call "symbolic play," such as pretending to be an animal or pretending to be feeding a baby doll.<sup>13</sup> These symbolic acts reflect the formation of mental schemas for objects and events and the ability to consider objects and events that are not present, all of which are an integral part of abstract thinking and cognitive development.



Gesture can be used to direct another person's attention to an object, or to hold one's own attention to that object. The use of gesture to gain and hold attention can have a powerful impact for social development because joint attention is a foundation for learning. Parents try to teach their children about objects by pointing, and they are likewise responsive to the gestures of children.<sup>14</sup> For example, a parent may point at a bird, produce "bird" in sign or speech, and gesture by waving arms as if she or he is flying like a bird. There is more new research showing that using gestures at home can lead to larger vocabularies in children15 because they promote richer dialogues between parents and children and thereby enrich social relationships.

#### How Can Gestures Help Learning? Clues from Hearing Students

Gestures that hearing people produce while speaking are called co-speech gestures. Co-speech gestures can contain information that is not directly mentioned in the spoken utterance.

To discover the role of gesture in learning, researchers have been studying how hearing children use gestures as they explain their answers while they are solving math and science problems.<sup>16, 17</sup> Students are given a set



of problems to solve and if they are unable to solve them correctly, they are provided instruction. The students are tested again to measure learning.

Learning requires a flexible state of thinking. Researchers have found that gesture can reveal insight into such moments of thinking. In hearing students, sometimes their spoken language expresses one idea but their gestures express a different one. These are called speech-gesture "mismatches," and they can indicate moments of flexible thinking.

This means that students who produce such mismatches are more likely to benefit from instruction than students who do not.18 Gestures can indicate transitional states of knowledge when students are ready to learn new concepts.

Researchers have wondered whether mismatches in language and gesture need to be expressed with two different sets of articulators, using the hands and speech, or whether mismatches are also be revealed with the hands alone.

In other words, are there mismatches in sign language and gestures too? Can using the hands for both language and gesture help learning?



#### New Findings: Gestures Tell Us When Deaf Children Are Ready to Learn Math

Goldin-Meadow, Padden, and their colleagues studied deaf children ages 9 to 12 learning math equivalence. The students were asked to solve problems such as:  $6 + 5 + 8 = \_ + 8$ .

Children at this age may know how to add and subtract, but many do not yet grasp the principle of equivalence. Understanding this principle is important for more advanced understanding of math.

Students who do not yet understand this principle will add up the numbers of the left side of the equation and give 19 as the number to place on the blank on the right side. Others may add up all numbers they see in the problem and put 27 as the answer. In this problem, the correct answer is one where both sides of the equation equal 19. The answer to supply for the blank is 11.

The deaf students in this study who

gave wrong answers were provided with instruction on how to solve the problem. The instructor pointed at the numbers on the left side and explained that the total amount on this side of the equation (indicated by a tracing gesture) must equal the right side of the equation (indicated by another tracing gesture).

Then the students were tested again with a new set of problems. The researchers wanted to know if the students' gestures as they explained their wrong answers in the first test might predict their readiness to learn.

Similar to the co-speech gestures of hearing children, deaf children produced co-sign gestures.

Hearing children can say the number "6" with speech and also use their hand to point to the number "6" on the white board. Deaf children can do the same, signing with one

hand and pointing with the other, or they can produce the handshape for "6" and place the handshape on the written "6" on the board.

Hand movements such as pointing, tracing, or sweeping movements on the white board were coded as gestures. The information in the students' signs was coded separately. The information conveyed in gestures was then compared to information conveyed in signs.

The study found that deaf children use gesture at approximately the same rate as hearing children while solving math equivalence problems. The study also found that deaf children can convey different information with their gestures than with their signs, leading to the discovery that mismatches do, indeed, occur in sign language.

The researchers also found that deaf children who did not use gestures in their explanations — that is, they used fewer pointing gestures to the board in their answers to the math problems — were less likely to succeed after instruction. The implications in this study are that gestures in deaf signing children do indeed help predict learning.

#### **Gestures That Teachers Use Can Boost Learning For Students**

Gestures that teachers use can boost learning for students as well.<sup>19</sup> In studies of natural classroom instruction, findings show that hearing students learn better when teachers gesture.<sup>20, 21</sup>

In science, gestures are used to convey concepts such as as the direction of a magnetic field relative to the direction of electric current or, in chemistry, how pairs of some molecules that are mirror images can be superimposed on each other, while others cannot (like the hands).

When students are taught math equivalence in experiments, they learn more effectively when the instruction is provided in speech and gesture rather than speech alone.<sup>22</sup>

Although most of the research on the role of gesture in instruction has been conducted with hearing children, there are implications for the education of deaf students.<sup>23</sup> When deaf students watch an interpreter, they may miss the gestures of the teacher as she explains concepts to the class. Interpreters often sit away from the board, which may

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mean that while the student is watching the interpreter, the additional information in the teacher's gestures is unavailable for the deaf learner.

Further research is necessary to determine the role of gesture in instruction for deaf students. Deaf students may benefit from having teachers who gesture while teaching new concepts or information (e.g. pointing to pictures, tracing numbers, simulating actions.) This will involve studying signing teachers as well as interpreters who work with hearing teachers.

Building upon converging evidence that learning is achieved more efficiently when the material is presented in multiple formats, researchers and educators will need to work together to make multimodal learning possible for deaf learners.

#### **Gesture and Spatial Reasoning**

In conversations, people produce more gestures when talking about spatial concepts during the description of movements and images.<sup>24</sup> This suggests that gesture can serve as an interface for spatial thinking and language.

There is growing interest in understanding the development of spatial skills because they are linked to success in math and science.<sup>25</sup> For example, mental rotation abilities can serve as a predictor of scores in the math section of the SAT exam used for college admissions.<sup>26</sup> It is estimated that spatial skills influence people's career choices; people with higher spatial skills are more likely to work in the fields of science, technology, engineering, and math (STEM).<sup>27</sup>

Gestures help hearing children perform better at spatial reasoning.<sup>28</sup> Signing experience has also been linked to enhanced spatial abilities.

Deaf and hearing signers are faster and more accurate at solving mental rotation problems than nonsigners.<sup>29</sup> This has been attributed to practice in following directions and spatial locations from the viewpoint of the signer. Moreover, children with early sign exposure perform better in tasks remembering a sequence of spatial positions than nonsigning children or children with late sign exposure.<sup>30</sup>

More research is needed to determine the impact of rich sign language exposure on the development of spatial communication skills and the implications for deaf children who do not sign. Additionally, more research is needed to determine how to leverage advantages in spatial processing among signing students for learning purposes.

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Although math equivalence problems may not generally be considered as requiring spatial reasoning, gesture may help students better understand the concept because they are using spatial strategies for solving the problems.

Solving math equivalence problems requires the student to understand the relationship between numbers on both sides of the equation and also understand that certain numbers group together. For example, to solve  $6 + 5 + 8 = \_ + 8$  requires a student to consider what happens with the 6 and the 5.

Gestures can be used to promote learning concepts even when that information is not given through language. Simply encouraging students to gesture without showing them how to gesture can help them discover new strategies for solving problems.<sup>31</sup>

For example, teachers can ask the students to show how to solve the problem by pointing, sweeping, or tracing on the board, and teachers can model how to solve the problem using gestures.

From different studies, researchers have learned that gesture and language support different kinds of skills and different ways of solving problems.<sup>32</sup> Using different modes of thinking — meaning a spatial, gestural mode or an abstract, language-based mode provide different advantages to a student.

#### Gesture and Language Development

In addition to studying how children learn concepts about math and science, gesture can be used to track language development.

Infants use gesture to communicate even before they utter their first words.<sup>33</sup> Children tend to produce a gesture for an object before producing a word for the same object.<sup>34</sup> In deaf children, early gestures can be used to predict early signs.<sup>35</sup> Single gestures precede single word utterances, and gesture+word combinations tend to precede word+word strings.<sup>36</sup>

Researchers studied hearing children who were learning both spoken Italian and Italian Sign Language and found that they produced gesture+word combinations before sign+word combinations; this is consistent with findings on the early role of gesture in language development.<sup>37</sup> Gesture serves as a stepping-



stone to language acquisition in both deaf and hearing children.<sup>38</sup>

Gesture also seems to be linked with vocabulary size, which in turn strongly correlates with language skills and academic performance.<sup>15</sup> In the homes of hearing children with larger vocabularies, researchers found that there was more gesturing by the children and their parents. In an experiment to encourage hearing children to gesture, researchers found that when the children gestured more, they used more words in their interactions with their parents.<sup>39</sup>

Gesture can pave the way for language development, which in turn serves as a foundation for learning and developing social relationships throughout life.

Absence or low use of gestures by a young child may indicate potential problems with language development. Because gesture often precedes milestones of language development, if parents and teachers can recognize delays in the use of gesture, they may be able to identify risks for language impairments and autism spectrum disorders earlier.<sup>40</sup>

To summarize, research on gesture demonstrates that the visual-manual modality plays an important role in cognition for all learners, not just signing children. It is especially interesting that gesture plays a role even in signing children's language development<sup>38</sup> and problem-solving.<sup>19</sup>

As a means of spatial cognition, gesture provides a window to the mind.<sup>41</sup> Gesture can indicate transitional states in learning and can help us find strategies for helping deaf children who already know sign language and who are learning how to reason about math and science. As we carry out research on the gestures of deaf children, our goal is to find ways of using both sign and gesture to aid learning in deaf children. It's important to understand the role of spatial communication among all children, and more research is needed to determine the impact of rich sign language exposure for the development of such skills.



#### **Implications for Parents and Educators**

Pointing gestures are important for sign language development. Parents should use them whenever appropriate, such as when using new signs and to explain events. Pointing gestures bind language to the environment and help adults and children to communicate effectively. Parents should also respond to pointing gestures used by their children and use their pointing as a guide for beginning and sustaining conversations with their children.

It is not necessary to learn how to gesture; it is more important to allow gesture to emerge spontaneously. Gesture naturally increases in detail when the topic turns to spatially complex ideas. But gesture is present even in normal everyday conversation.

When teaching math and science, teachers should try to be in an ideal position to point and use other gestures while explaining concepts in front of a board or when interacting with physical objects in the world.

Hard of hearing children who are learning spoken language should not be discouraged from using gestures. Also, adults communicating with deaf and hard of hearing children should not refrain from using gestures. Gesture should be used naturally with either speech or sign.

Although research on this topic is still new, it may be valuable to alert sign language interpreters to the importance of gesture and encourage more natural pointing and gesturing during interpreting (such as pointing to the board where the teacher is standing or pointing to material on the board).

#### **Collaboration with Other Centers**

This project on the role of gesture in learning among deaf children was supported by the National Science Foundation's Science of Learning Center on Visual Language and Visual Learning (VL2) and the Spatial Intelligence Learning Center (SILC).

#### **Translating VL2 Research**

The National Science Foundation Science of Learning Center on Visual Language and Visual Learning (VL2) publishes research briefs as a resource for parents, educators, and others who work with deaf and hard of hearing children. These briefs review important research findings, summarize relevant scholarship, and present informed suggestions for parents, educators, and professionals. The information provided in this brief is intended to explain the role of gesture in child development and learning.

#### VL2 Resources for Your Family and Your Classroom

Scientific discoveries from the National Science Foundation Science of Learning Center on Visual Language and Visual Learning (VL2) at Gallaudet University have provided foundational knowledge that has been used to create important evidencebased translational resources.

Key discoveries that contribute to VL2's translation of science span multiple VL2 laboratories and include the discovery that early exposure to a visual language provides visual processing and higher cognitive processing advantages; early bilingual ASL and English exposure provides powerful dual language benefits; and visual sign phonology plays an important facilitative role in the young deaf child's early acquisition of reading English in the same way that sound phonology has a facilitative role in young hearing children's accessing of meaning from English print.

VL2 has created translational, educational, and ethical resources for educators, practitioners, policymakers, parents, researchers, and the greater public. For more information, see:

- <u>vl2.gallaudet.edu</u>
- <u>www.vl2storybookapps.com</u>
- <u>www.vl2parentspackage.org</u>

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