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VISUAL LANGUAGE & VISUAL LEARNING

RESEARCH BRIEF:

VISUAL LANGUAGE & VISUAL LEARNING

VISUAL ATTENTION AND DEAFNESS

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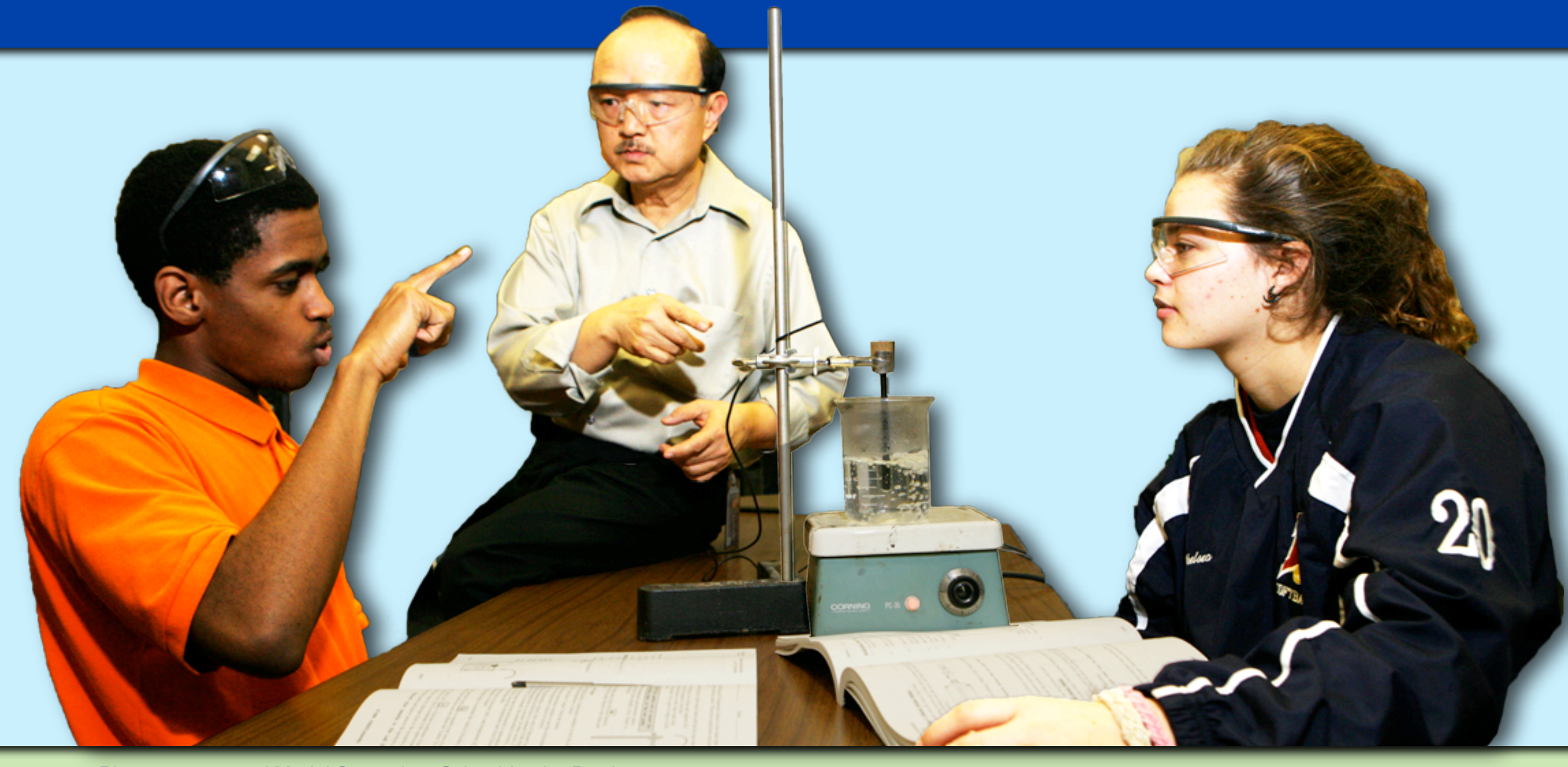

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LEARNING FROM RESEARCH # 3

Key Findings on Visual Attention and Deafness:

- Deafness leads to changes specifically in visual attention, but not in all aspects of vision.
- Deafness enhances visual attention in the periphery.
- Evidence for changes to visual attention in the periphery can be observed in the brain.
- Changes in visual attention could have implications for reading and the ideal classroom environment.

Visual Selective Attention and Deafness

A common concern among parents and educators of deaf children is that they seem easily distracted and hard to keep focused in a busy environment. This observation is essentially describing a problem with visual selective attention. Visual selective attention refers to the ability to pay attention to things that are relevant to current goals while ignoring distractions that are not pertinent. In an educational setting, selective attention means that an individual is able to focus upon a teacher or interpreter while ignoring a bird flying by a window or a student walking by an open classroom door.

A Problem, or just a Different Way of Seeing?

There is some seemingly contradictory evidence in the literature on the effects of deafness on visual attention, but this discrepancy is largely a result of studying different deaf populations and also using different measures of visual selective attention. Individuals in the deaf population are quite diverse in regards to their preferred type of communication (sign language, oral communication, etc.), the age of acquisition of their native language, the hearing status of their parents, their hearing loss etiology (genetic, infection, etc.), and cochlear implant use (age of implantation and years of use). Most of the research suggesting that deaf children have problems with selective attention have focused on deaf children learning spoken language; these studies have looked at how their visual selective attention changes after restoration of auditory input through a cochlear implant.[1,2,3]

Rather than thinking about the attention of deaf individuals as a concern, several researchers have come to think about this issue from a different perspective: not as a problem, but rather as a different way of processing visual information. There is mounting data that shows improved performance in visual attention in deaf individuals; this data suggests that the visual system compensates for the lack of auditory input.[4]

Studies reporting better visual selective attention skills have been conducted with deaf adults, specifically those born to deaf parents and who acquired American Sign Language (ASL) as a first language. This is a good population to study the effects of deafness because deaf children who have early and full access to language have typical cognitive and language development from birth and reach the same milestones as hearing children. In these individuals, VL2 researchers Matthew Dye, Peter Hauser, and Daphne Bavelier--among others--have reported enhancements in selective attention in the visual periphery.[5] This finding suggests that the visual system compensates for the lack of auditory input by enhancing the monitoring of the peripheral visual field.[4]

While deaf individuals do display differences in visual attention, it is important to note that not all aspects of vision are different in deaf and hearing people. Purely sensory visual abilities, like the ability to discriminate shades of gray,[6] the ability to distinguish between quickly flashing items,[7] and basic visual motion processing[8,9] are similar in both deaf and hearing individuals.[4] This finding dispels the widely-accepted idea that loss of hearing leads to changes in abilities in other senses. Vision does not change—visual attention does.

Changes to Visual Attention in Time and Space

Visual selective attention has more than one component.[10] For example, we can pay attention to areas in the visual field (spatial attention) or allocate our attention for a period of time (temporal attention). A series of studies conducted by VL2 researchers have demonstrated how these abilities change throughout development in deaf individuals.

Most studies that report a visual attention deficit in deaf children have examined *temporal* visual attention in children who have cochlear implants and who are also learning English. In contrast, VL2 researchers, Dye, Hauser, and Bavelier looked at changes in temporal *and* spatial visual attention at different stages of development of deaf native signers.

Tests of temporal visual attention are important in assessing one's ability to monitor the environment and remain alert, even after one's attention has been used on something else. These tasks measure important abilities for everyday skills like driving or navigating in a busy scene. Early in development, native signing children (up to age 10) are less able than age-matched hearing controls to monitor and identify specific predetermined targets when they appear in a constant stream of objects.[5] However, this deaf-hearing difference is not observed in adulthood (ages 18-40). In another test of temporal visual attention, participants were required to identify the second of two objects presented *extremely* quickly in succession (a test of *recovering* attention in time); in this test, there were no group differences between deaf and hearing individuals in either age group. These studies highlight the specificity of changes in visual attention: difficulties are limited to early childhood and are only observed when identifying pre-specified targets in a rapid stream of visual information.

Studies of spatial visual attention tell a different story. Enhanced spatial visual attention, or the redistribution of attention towards the periphery of the visual field, occurs quite slowly. When asked to focus on the center of the screen and to respond as quickly as possible to a target near the center or the periphery, elementary school age deaf children (7-10 years old) still perform similarly to their hearing peers.[11] The redistribution is observed around 11-13 years old and becomes marked around 14-17 years of age.[11] At that age, deaf individuals have a selective enhancement for detecting static or moving stimuli in the periphery.[12,13] Accordingly, they are also more affected by distracters in the periphery.[14,15] While greater distractibility typically reflects an attention deficit, in the case of deaf individuals it arises from greater processing resources allocated to the periphery.

Deaf individuals are not necessarily more distractible but are more distracted by peripheral events; hearing individuals are more distracted by central events.[14] These effects of enhanced peripheral attention in deaf individuals may even be intuitive. In order to adapt to the environment, a redistribution of visual attention to the periphery can compensate for the lack of peripheral auditory cues, such as what a hearing person would experience when a car approaches or someone opens a door.[16]

When using deaf native signers as the target population, it is always important to be able to dissociate potentially separate effects of deafness and sign language use. By comparing both deaf and hearing native signers, it has been confirmed that the peripheral attention benefits seen in deaf native signers are due to deafness and not sign language use; hearing native signers do not show the same effects of greater visual attention in the periphery, but deaf non-signers do.[11, 14, 17, 18]

The reasons for possible early deficits in visual attention are harder to determine. Possible explanations include poor early access to a natural language, a situation that produces complex cognitive effects, but determining this would require comparing native signing children to deaf children with a language delay. Perhaps a more likely explanation is an early period of reorganization of the visual system. During this period, attention to the central visual field is sacrificed for peripheral attention, with later development leading to an improvement in the central visual field resources--to typical functioning level--all the while maintaining the peripheral advantage. Ongoing research, supported by VL2, is testing this latter hypothesis by looking in detail at visual selective attention across time and space in 6-13 year-old deaf, signing children and their hearing peers.

Cross-modal Plasticity and the Brain: How Deafness and Sign Language Change Brain Organization

Cross-modal plasticity refers to neural reorganization that occurs due to sensory deprivation. Reorganization due to deafness could take place in the "deprived" parts (e.g. auditory areas) or the non-deprived parts (e.g. visual areas) of the brain. Because enhanced peripheral visual attention is observed in deaf individuals, researchers have investigated how these differences are realized in the brain. Neurological data does, in fact, mirror behavioral evidence that there are differences between deaf and hearing for visual attention tasks in the periphery, but only for *attended* stimuli. For example, when told to pay attention to motion in the periphery, deaf individuals display greater neural responses[19] and greater recruitment of motion processing areas in the brain,[18] whereas deaf and hearing have equivalent neural responses to *unattended* moving objects.[20]

There are several theories as to how the brain might reorganize that could account for the behavioral data. The *first* theory is that there could actually be changes in early visual areas, those parts of the brain that process perceptual visual information received from the eye (and thus not necessarily affected by attention). However, the literature does not support this notion,[21] as deaf and hearing individuals show no difference in size or activity level in such areas. The fact that there are no purely perceptual behavioral differences between deaf and hearing individuals is consistent with these results.

A *second* theory is that the areas of the brain where information from different modalities is integrated may get greater input from vision. This gains some support from data showing changes in such 'multimodal' areas in deaf individuals,[18] but more research is needed to strengthen this view.

A *third* theory is that the deprived auditory brain areas reorganize in order to better process visual information. Greater activation in auditory brain regions has been reported in deaf individuals for visual, tactile and sign language processing.[22,23] Moving visual stimuli activate right hemisphere 'auditory processing areas' in deaf individuals[23] in a region that is specialized for processing auditory motion in hearing individuals.[24] The idea is that the same brain area that is typically involved in a distinct function in one modality (e.g. processing of motion in the environment through the auditory modality) can be used for the same function, but in a different modality (e.g. motion, but this time in the visual modality). This shift happens after sensory deprivation--a hypothesis supported by animal literature.[25]

Relevance to Parents and Educators

There are several take-home messages here for those interacting with deaf individuals on a daily basis.

Ideal Learning Environment

Current research proposes that deaf children have a difference in attentional allocation that is slow to develop. For that reason, the classroom environment that is good for one grade level may not be appropriate for another. Problems could arise when demands of the environment or task (e.g., looking at a teacher or interpreter) conflict with the default allocation of attention for whatever stage of development a deaf child is in. For example, later in development (starting around age 11) more allocation is given to the periphery when the timing and location of distractions are unknown. For this age group, placing students in areas where distractions are unlikely, but inconsistent, may actually be counter-productive because they would be constantly using attentional resources to monitor the periphery. A beneficial learning environment for such students would be one with predictable and consistent surroundings. Additionally, small class sizes and having the students sit in a semi-circle may also be beneficial.[16]

Effects of Changes to Visual Attention on Reading

In addition to the multitude of reasons why reading English is a complicated challenge for deaf children, changes to visual attention in deaf individuals may also have implications for how they read.[26] Research in hearing individuals tells us that reading involves using the center of our visual field to fixate on words. If deaf individuals naturally pay more attention to items in the periphery, this may result in confusion in identifying letters and words, longer fixations, and slower reading times. This extra time may also result in taxing other cognitive processes like memory in order to fully integrate all of the information in a complicated sentence. A 'windowed reading' technique, where words are visually presented in smaller chunks, has been suggested as a good technique for limiting distracting information in the periphery. While more research is needed, it is useful to keep in mind possible additional challenges for deaf readers that are related to changes in visual attention.

Unanswered Questions and Future Research

- Taking into account new knowledge of what is normal attentional development in deaf signers, how should psychological evaluations in the deaf population be conducted and/or altered?

- How can teachers and educational administrators for deaf individuals take into consideration the unique strengths of deaf individuals when developing teaching strategies and curricula?

- Because this research brief has focused on the deaf native signing population, it is important to research how generalizable the reorganization observed in deaf signers is to the remaining 95% of the deaf community who are born to hearing parents. Typically, this larger percentage of deaf individuals are not raised with access to fluent users of ASL during infancy and early childhood.

Integration of Research in Education

VL[2] publishes research briefs as a resource for educators and parents. The goal is to inform the education community of research findings, to summarize relevant scholarship, and to present recommendations that educators and parents can use when addressing the multifaceted challenges of educating deaf and hard of hearing children.

Research briefs are available under Publications & Products at vl2.gallaudet.edu.

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