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journal or publication title	Journal of social policy and social work
volume	19
page range	5-17
year	2015-03
URL	http://id.nii.ac.jp/1137/00000336/

Cognition of Children with Hearing/Visual Impairments and its Applicability to Language Teaching: Toward Barrier-Free Elementary School English Education

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Abstract

In this article cognition of children with hearing/visual impairments are applied in foreign language teaching, especially elementary school English. Firstly, the most recent cognitive assessments and experiments are reviewed. Secondly, the English teaching materials provided by the Japanese ministry (MEXT) are examined, which can be improved, by making the best use of the cognitive characteristics of hearing/visual impaired children. Finally, the applicability of neuro-science, including unplugged environment, is discussed. The educators should notice that there are children who listen through eyes, or see through ears, and since every child has his/her own cognitive tendency and characteristics, barrier-free teaching materials/methods made by the staff including hearing/visual impaired educators, are ideal for all children and for any language, which can be called universal design for foreign language teaching.

Keywords; cognition, hearing impairment, visual impairment, foreign language learning

Introduction

This is a part of the research project by Grants-in-Aid Scientific Research(B) on Barrier-Free Elementary School English Teaching Materials/Methods Using Cognition of Children with Visual/Hearing Impairments. Although the ultimate goal is, therefore, to develop the teaching materials/methods, the purpose of this article is to explore cognitive characteristics of children with hearing/visual impairments in order to apply them to foreign language learning /teaching.

MEXT (Japanese Ministry of Education, Culture, Sports, Science and Technology) made English compulsory to elementary school children in 2011. Putting the pros and cons of teaching English in elementary school aside, it is urgent to improve English teaching materials/methods for hearing/visual impaired children, because they are left behind from other children. It is noteworthy that, owing to technological development, more and more hearing/visual impaired individuals have an interest in correspondence with non-Japanese people, and some of them are even working or studying abroad. Therefore improvement of English teaching for young children is important not only as "reasonable accommodation" prescribed in Convention on the Rights of Persons with Disabilities but also for their future career and full life.

This article explores the applicability of cognition of children with hearing/visual impairments in order to improve language teaching for them. In chapter I, the most recent cognitive assessments and experiments are reviewed including those using the neuro-scientific technologies such as PET (Positron Emission Tomography) and fMRI (functional Magnetic Resonance Imaging) to explore the characteristics, especially "*advantages*", of hearing/visual loss. In chapter II, the English textbooks and the teachers' guidebook provided by MEXT are examined from the viewpoint of cognitions of children with hearing/visual impairments, and the necessity of accommodation will be pointed out. Finally, chapter III will propose the improvement of English teaching materials/methods for hearing/visual impaired children based on recent cognitive science and its application to ICT, with reference to UDL (Universal Design for Learning) in US. The application of neuro-science to foreign language teaching should be effective for every child, whether he/she has impairments or not, because every child has his/her own cognitive tendency and characteristics (Saito 2009). UDL cannot be realized without involvement of teachers and supporters with the same cognitions as the children with hearing/visual impairments. Accommodation for hearing/visual impaired children tends to be thought as economic and psychological burdens in educational settings, but it can profit all the children.

In this article some abbreviations such as PET, fMRI, MEXT, and UDL are used as above. In addition, ASL stands for American Sign Language, JSL stands for Japanese Sign Language, and SSD stands for Sensory Substitution Devices.

Ⅰ. Cognition of Hearing/Visual Impaired Children

In this chapter, cognitive assessments of children with hearing/visual impairments will be discussed, following the review of recent neurological findings.

1. Difficulties in Assessments and Misunderstanding about Haring/Visual Impaired Children

Cognitive assessments of hearing/visual impaired children have been problematic, since assessment tests have long consisted of intelligence tests that were not well-applied to children with different modalities in their communications from the majority of children (Maller and Braden 2011). The researchers have lacked the skills to assess cognition not using visual/hearing perceptions. In addition, it is difficult to obtain sufficient sample sizes to conduct the necessary investigations due to the fact that populations of hearing/visual impaired constitute diverse groups in terms of communication methods/styles, degree of hearing/visual loss, age of onset and educational settings (e.g. parental hearing/visual loss, special school or general school). Therefore the results have been chaotic and confusing.

Studies on cognitive functioning have made up such images as "the deaf as inferior" and "the deaf as concrete" (the deaf do not understand abstract concept) (Marschark and Wauters 2011). The problem here is that their intelligence have been examined by verbal intelligence tests. "Verbal" means phonetic languages such as English and Japanese. Many psychologists and educators noticed that the deaf had the handicap in learning "languages". "Languages" here mean phonetic languages in written forms. In nonverbal tests, such as WISC-R and WISC-III, deaf children showed better performance than in verbal tests, but the results of the deaf children varied and they were similar or worse than hearing children. Deaf examinees did not always understand the directions and instructions presented in phonetic languages (Spencer and Marschark 2010).

It has often been thought that blind children have delays and deviations in language acquisition. The lack of over-generalization and the reduced number of word inventions are reported (Anderson et al 1984; 1993). However the linguistic problems of blind children reflect a more general deficit, for example, recognizing and grouping objects by visual features, such as motion, color and shape (Cattaneo and Vecchi 2011). Blind people usually have a good knowledge of colors, which is mediated by language. They have no qualia associated with the sensory experience.

Röder Brigitte and Frank Rösler (2003) proved that blind adults showed elevated memory both after physical and semantic encoding. After physical encoding blind subjects had lower false memory rates than sighted subjects. After semantic encoding the false memory rates of sighted and blind subjects were the same. Late blind adults were tested with the same paradigm and the results were not different. This depends on the ability of blind people to compensate for their lack of visual inputs by developing conceptual networks with more auditory and tactile nodes (Cattaneo and Vecchi 2011).

The problem of cognitive assessments is not only in language, but in cognition itself, or in the way of thinking and social functioning. Hearing loss and the use of sign languages influence attention, perception, mental representation, visual imagery and memory (Marschark and Wauters 2011).

In addition, discussing cognition of the "hearing impaired" is very complicated. Hearing impaired constitute deaf and hard of hearing with various degrees of hearing loss. Deaf children comprise a various groups in terms of age of onset and family backgrounds. Early onset of hearing loss, that is pre-lingually deaf, is different from other hearing impairments as discussed below. Also hearing impaired children who have deaf signers as parents are also very different from other hearing impaired children, because they have cognition built up by sign languages whether they are hard of hearing or deaf. Sign languages, such as ASL and JSL, have totally different grammatical structures from phonetic languages (e.g. directions of hand movements as case-indicators), which build up native signers' unique cognitions.

In the following sections, the most recent cognitive assessments and findings will be reviewed including experiments using PET and fMRI in order to explore the characteristics of hearing/visual loss.

2. Cognition of Hearing Impaired: Impact on Visual Cognition

Children who implant artificial cochlear implants after the end of sensitive period (i.e., after age 7) show "low-amplitude, diffuse activity from the primary generators identified in the normal hearing and early-implanted children" and have "significant deficits in oral language acquisition" (Sharma and Mitchell 2013, p. 199). This is regarded as *low success rate of implantation* from a negative viewpoint, while it can be regarded positively as *cross-modal plasticity*. Instead of encouraging the early implantation, some people, especially those respecting "Deaf Culture", appreciate *the visual ability* of deaf children. P. M. Gilley et al. (2010) report that the late-implanted children show activation of anterior parietotemporal cortex, insula, and areas of *visual cortex* by *auditory stimulation.*

Although the auditory stimulation in most of early–implanted children activate auditory areas which are associated with normal auditory processing, the training and rehabilitation are necessary and all of early-implanted children do not necessarily save themselves from deficits in oral language acquisition. They also have five times the risk of having delays in executive functioning; areas of working memory, controlled attention, planning and conceptual learning as children with normal hearing (Kronenberger et al. 2014). It is important to notice that cognition of implanted children are not the same as hearing children, even if they apparently "hear" as hearing children.

The following two experiments show the cognitive effects of neuro plasticity. One is the McGurk effect which is auditory-visual illusion when the sound is presented with the visual cue. For example, when visual cue of /pa/ is showed with the sound /ka/, most listeners report they heard the /ta/ sound. J. Rouger et al. (2008) report that children with cochlear implants showed greater visual dominance (more instances of /pa/) than normal hearing children (more instances of /ka/) and that none of the late-implanted children showed bimodal fusion. Also, measuring reaction times to auditory tones, to visual flashes and combined auditory-visual tones and flashes, late-implanted children show visual dominance, while early-implanted children do not (Sharma and Mitchell 2013). Thus the absence of auditory input from birth changes the way that visual information is processed. These consequence can be considered *adaptations* to the absence of auditory input.

Recent studies are also discovering how the use of a visuospatial language might influence deaf children's language, cognitive and social functioning, which offers "great hope for improving deaf education" (Marschark and Wauters 2011). Deaf signers have better cognition to letter especially when the letters move in radiating way (Saito 2009). They also perceive words in two or three lines simultaneously, while hearing people perceive sentences in a linear way, from left to right (Saito 2000).

K. Meadow-Orlans et al. (2004) measured play differences of 18-month-old children, both hearing and hearing–impaired, in terms of representational level and symbolic level to find that the differences related NOT to hearing status but to their language (either phonetic or sign language) level, though there was no play differences at 9-months-old children. They also analyzed the differences in cognitive play behavior of 24 to 28 -months-old children of three groups, that is, hearing children with hearing mothers, deaf children with hearing parents, and deaf children with deaf mothers. The results related not to hearing status, but to language level, and further the group with lower language skills was composed mainly of deaf children with hearing mothers.

In addition to deafness, early language experience impacts brain structure. Daphne Bavelier et al. (2001) found the impact of early auditory deprivation and/or use of **ASL** on the organization of neural systems. It affects visual motion processing.

Deaf children with deaf signing mother are more visually distractible and they have high cognitive sensitivity to peripheral visual field (Spencer and Marschark 2010). They are good at face discrimination and recognizing rotations in three-dimensional block figures (Emmorey 2002).

According to Olumide A. Olulade et al. (2014), half of their subjects (deaf and hearing) of fMRI experiments had learned ASL as children from their deaf parents, while the other half had learned English from their hearing parents. They found specific difference in left hemisphere language areas. Although their former researches had shown that people who are deaf and hearing differ in brain anatomy, these studies have been limited to studies of **Deaf ASL users** from birth. But 95 percent of the deaf population in America is born to hearing parents and use English as their first language through lip-reading. The result of 2014 research shows there is a difference in how brain operates between deaf children with hearing parents and those with deaf parents who sign.

3. Cognition of Visual Impaired Children: Impact on Tactile and Auditory Cognition

Educators intuitively believe that blind people compensate their visual impairment with auditory and somatosensory (including tactile) systems. Several studies demonstrate enhanced auditory processing in the visual impaired.

Robert Weeks et al. (2000) have measured, using PET, the regional cerebral blood flow in sighted and blind subjects performing auditory localization tasks. During the task, both groups of subjects activated posterior parietal areas. Blind subjects, however, also activated association areas in the right occipital cortex, which were similar areas as previously identified in visual location and motion detection experiment in sighted subjects. Thus the blind demonstrates visual to auditory cross-modal plasticity.

P. Voss et al. (2011) showed, using PET, that the superior ability of early-onset blinded subjects to localize sounds was mediated by their superior ability to use spectral cues, which was subserved by cortical processing in the occipital cortex. They also showed that more occipital recruitment was associated with better performance in early- and late-onset blinded subjects but not in sighted subjects.

Merabet et al. (2008) proved that even a few days of binocular deprivation caused colonization of visual cortex by auditory and somatosensory systems. Laurent A. Renier et al. also found (2010), using fMRI, that visual cortex of the brain of people who have been blind from birth was used for perceptions of sound and touch. They conclude that it helps the blind to navigate better in the world. This kind of rewiring, though, is thought to be easier for the brain early in life, which M. Bedny et al. (2010) offers evidence for. They found that a small part of the brain's visual cortex that processes motion was reorganized only in the brains of subjects who had been born blind, and not those who became blind later in life. They concluded that the brain is wired during the first few years of life (Bedny 2010). Frederic Gougoux et al (2004) showed that the younger the onset of blindness the better was pitch discrimination and Goldreich and Knics (2003) found that only congenitally blinds have enhanced tactile discrimination. Thus early onset of blindness effects brain re-organization, as in the case of hearing impaired.

According to Patrice Voss and Robert J. Zatorre (2012), those who become blind at an early age can hear notes more precisely than those with sight or people who go blind later in life. They summarized sound tests on sighted subjects as well as others who went blind before the age of two and a group whose members lost their sight between the ages of five and 45. The group who went blind before the age of two were able to correctly distinguish notes 10 times shorter in duration than those recognized by sighted subjects.

A. A. Stevensa and K. Weaver (2005) tested the hypothesis by H. J. Neville and D. Bavelier (2001) that faster temporal processing underlies many auditory compensatory effects. They tested early-onset blindness subjects and sighted subjects using TOJ (temporal-order judgment test) of auditory stimuli and the result was that early-onset blinded subjects showed better performance. They concluded that advantages in perceptual consolidation reflect a mechanism responsible for the short response times.

As for sound perception, Thaler et al. (2011) report echolocation is used by blind people, as bats and dolphins. There are blind people who have learned to make clicks with their mouths and to use the returning echoes to navigate unknown environments. The researchers made recordings of the clicks and their very faint echoes by microphones when the blind stood outside and tried to identify different objects. the researchers played the recorded sounds back to the echolocators while their brain activity was being measured in fMRI. The blind perceived the objects based on the echoes showing activity in those areas of their brain that process visual information, not auditory information in sighted people.

The blind's ability to read Braille has been beyond explanation. It is impossible for sighted people. A. Bhattacharjee et al. (2010) conducted vibrotactile masking experiments and found that congenitally blind braille readers had special cognition. They tested the tactile skills of 89 people with sight and 57 people with visual impairment who were asked to discern the movements of a small probe that was tapped against the tips of their index fingers. The two groups performed the same on simple tasks, but when a small tap was followed immediately by a larger and longer-lasting vibration, the vibration interfered with most participants' ability to detect the tap ("masking") except for the 22 people who had been blind since birth. This interference happens because the brain has not yet completed the neural processing required to fully perceive the tap before the vibration arrives and disrupts it. The 22 participants read Braille fastest.

The question is, whether such special tactile sense is caused by daily dependence or vision loss alone improves tactile sensitivity. Michael Wong et al. (2011) examined it under the assumption: if using Braille improves tactile sensitivity, blind Braille readers would show particular sensitivity on their reading fingers and if vision loss alone improves tactile sensitivity, blind participants would outperform the sighted on all body areas. Twenty-eight profoundly blind participants—with varying degrees of Braille expertise—and 55 normally sighted adults were tested for touch sensitivity on six fingers and both sides of the lower lip. Researchers used a specially-designed machine which held the pad of the participant's fingertip perfectly still for the experiments. While the finger lay over a hole in the table, the machine pushed rods with textured surfaces through the opening until they met the fingertip. Researchers asked subjects to identify the patterns by touch. A similar test was performed on the lower lip. Not only did blind participants do better than their sighted peers, but Braille readers, when tested on their readings hands, outperformed nonreaders who were also blind. For Braille-reading participants, their reading fingers were more sensitive than their non-reading fingers.

Not only proficient Braille readers performed remarkably better, but also blind and sighted participants performed equally when the lips were tested. Braille readers here were blind people who spend hours a day reading with their fingertips.

Thus neurological researches on hearing/visual impairments prove that loss of one cognitive sense could be advantageous to other cognitive abilities revealing remarkable plasticity of children's neuro system. These neuro-scientific findings could be applicable to language education.

Ⅱ. The Applicability of Cognition of Hearing/Visual Impaired Children to Foreign Language Education

When children learn a foreign language, neuro systems which have already built by children's impairments and by their native languages should be made full use of, because it is obviously stressful for children to be forced to learn a new language through neurologically difficult systems. Needless to say, it is nearly impossible to learn through modality for which they have impaired. In the following discussion, teaching materials/methods of Japanese elementary school English will be examined in terms of modalities and hearing/visual impairments.

1. Japanese Textbooks of Elementary School English

Japanese Ministry of Education, Culture, Sports, Science and Technology has promoted English Education for elementary school children. However, the textbooks *Eigo Note* (English Note) *1* and *2*, which the ministry distributed to elementary schools from 2009-2011, and their accompanying guide books, have no consideration for hearing/visual impaired children. The textbooks and the guidelines are far from "reasonable accommodations" prescribed in Convention on the Rights of Persons with Disabilities.

Eigo Note 1, for example, begins with the greeting lesson as follows. It is practice of how to greet and how to introduce oneself. There are pictures of children from nine countries with the greeting words in their respectable languages such as "Hello," "Bonjour," "Jumbo," and "Konnichiwa". There are columns, "Let's Listen", "Let's Chant" and "Let's Play". In "Let' Listen", children listen to the words on CD and point the word and the country on the map on the page. This activity makes no sense to deaf children and it is difficult for children with hard of hearing. On the other hand, visual impaired children can listen to the words, but cannot see the map. Therefore this activity does not make any sense to them, either. "Let's chant" is effective for visual impaired children, but deaf or hearing impaired children cannot hear the model sound nor can they "chant" well. In the game "Let's play", children move around showing one picture card to other children and when they find the partner with the matching card, they greet each other in the language according to the clue the card has. This activity also needs both auditory and visual cognitions. The final activity is making name cards. The card on the page has the letter "SUZUKI KEN" with the pictures of a soccer ball, a dog and a boy. The guidebook suggests teachers instruct the children saying in English "Draw your face and your favorite things here."

2. Situations of Educational Settings and Necessity for Accommodation of English Teaching Materials/Methods

Most Schools for Special Needs Education cannot afford to offer English classes in the elementary school level. And it is not obligatory, which is another problem, because "excuse" is not "reasonable accommodation." The frontier school is groping how to teach English. For example, Special Needs Education School for the Deaf, University of Tsukuba, has tried to teach *Eigo Note 1* using alphabetical letters with *Katakana* letters (Seki et al. 2012). They do not use the CD. It is effective for hard of hearing to some extent. For deaf children, *Katakana* does not make sense. Special Needs Education School for the Visually Impaired, University of Tsukuba, makes the English teaching methods open on the internet, but it is for junior high school and not for elementary school. It starts with how to write/read English in Braille. Older Braille users realize and insist the importance of Braille, although with spread of sound conversion less and less young blind population learn Braille. Their tactile sense is reflected in the visual cortex, as has been mentioned in Chapter I, which means they "see" by fingers. But learning English Braille is extremely confusing for young children who are not fluent in Japanese Braille. For example, English Braille "l" is the same as Japanese Braille "ni", "m" is the same as Japanese Braille of "nu". Therefore children become fluent in Japanese Braille, before English Braille should be introduced.

In general classes, if there is a hearing/visual impaired child, the teacher sometimes uses another child as a listening partner, rotating assignments such as turning to the correct page and taking notes. The class usually has adult supporters, which causes psychological problems. Some teachers expect "normal" hearing ability when children wear hearing aids or a cochlear implant, or expect "normal" visual ability when children have magnifier. But these assumptions are incorrect. Most children with hearing/visual impairments are used to pretend they hear or see. Also as mentioned in the previous chapter, even if children actually "hear" by cochlear implantation, the brain system can be still deaf or hearing impaired.

Japanese special education has aimed at improvement and supplement of cognitive loss or impairment. However, as discussed in chapter I, the loss of one cognitive sense could be advantageous to other cognitive abilities, especially for children, because children's neuro system has remarkable plasticity.

Cognitive characteristics of hearing/visual impaired children and neuro-scientific findings about them presented in chapter I are applicable to these textbooks and teaching methods using them. Also, as discussed in chapter I, native language (or language use in early age) impacts on neuro systems for hearing/visual impaired, which leads us to new perspective that foreign language education is possibly an impact on neuro system of children. Given that English is going to be obligatory subject from third to sixth grade of elementary schools in the near future, how to teach effects not only English proficiency but also children's neuro systems. This is the ground for educators who insist that children should begin to learn English earlier, but it will be long before how cognitive characteristics are changed by English is disclosed. In the next chapter, applicability of cognitive characteristics and neurological plasticity will be presented, referring to UDL.

Ⅲ. Toward Universal Design: The Applicability of Cognition of Children Including Hearing /Visual impaired.

In contrast to Japanese teaching materials/methods discussed in chapter II, UDL and other researchers of ICT in USA consider the characteristics of hearing/visual impaired and neurological plasticity of children. In this chapter, these principles and devices are introduced, and the applicability of cognitive and neurological findings of children with hearing /visual impairment to language teaching will be discussed.

1. ICT for Universal Design for Language Teaching

UDL has developed in USA, especially since economic recession in 2007 as cost-cutting measures, as well as necessary accommodation in general education classrooms which have routinely students with disabilities and English Language Learners. Emiliano Ayala et al. (2012) state:

> Digital media (text, graphics, video, audio) economize the representation of information in multiple modalities. The online environment offers students multiple means on expression by adding threaded discussion, forum, and/or text chat options … The shift to digital instructional materials significantly enhances the flexibility of classroom learning resources --- a core prerequisite of UDL. Web-based content can be accessed from home as well as from school. (p.137)

Braille translators such as Perkey or tactile technology such as iPad Mini retina display are useful for visual impaired children. The software such as Dragon Dictation transcribes speaking words and iAS translates English to ASL.

The book called "Reach for the Stars: Touch, Look, Listen, Learn" is designed for visual impaired. It depicts stars with sound and tactile overlays; the brighter the star, the higher the pitch. The temperature of a star is conveyed; the reader hears about a cooler stars through the left ear and hotter stars through the right ear. They provide tactile overlays for about 10-12 images which have raised textures representing important features in the images (STS cl, 2014).

Further, SSDs can convey color and shapes to the brain through other senses. Using this SSD equipment and a unique training program, the blind are able to achieve various complex, visual-linked abilities. Although it is not yet popular, new technological advances enable SSDs to be much cheaper, smaller, and lighter, so that they can run on Smart Phones.

Computer games using sounds and tactile sense are also effective. M. Matsumoto and M. Sakajiri (2013) developed a role playing game converting the movement of characters into sound of footsteps or using the changing the volume of sound effects (e.g. sound volume is down when the character moves away from the center of the screen). They also developed touch panel screens so that the users could know the view and scenery.

Japanese teaching materials such as *Eigo Note* introduced in the previous chapter are not conformed with universal design. The teachers do not have enough opportunity to obtain neurological information. Japanese ICT is on a high level, but it is hardly used for handicapped students. *Eigo Note* uses no ICT except for CD which disregards hearing impaired children. Taking a long-term view, using ICT is cost-cutting. The ICT devices as mentioned above, can be applied to *Eigo Note*, translating one modality to another and making games instead of moving activities. "Reach for the Stars: Touch, Look, Listen, Learn" can be rearranged to map of the world in *Eigo Note*.

In UDL the role of teachers is less focused in offering information and opinion, and more focused on guiding students in how to learn, including how to use digital media and networked technology in schools. Digital media (text, graphics, video, audio) economize the representation of information in multiple modalities.

Whether in schools for children with special needs or in general classrooms, hearing/visual impaired children vary in terms of communication methods/styles, degree of hearing/visual loss, age of onset and parental hearing/visual loss. Also the apparent degree of hearing /visual loss produced by cochlear implants, hearing aids and magnifiers do not necessarily reflect their neurological states or real cognition. It is nearly impossible for teachers to grasp neurological states of individual children. Multiple means of representation and expression are necessary. The teacher should have neurological knowledge to some extent.

It is also preferable for each child to adjust learning materials according to impairments. Saito (2009) developed self-learning software for university students aiming at Barrier-Free English education in which the sound and image are adjustable for each individual learner. First a software of auditory materials for blind learners and a software of visual materials for deaf learners were designed. Next the two softwares were combined in which learners, including students with hard of hearing, low-vision and other students with *NO* impairments, can adjust the size of letters, movements of words or sentences and the volume of sound. For children's English education, it should further include pictures, animations and songs, and preferably, tactile raised images or Braille on touch panel should be available in the future.

2. Unplugged Universal Design

Even if Japanese educational settings cannot afford to improve teaching environment, the unplugged universal design is possible. David Rose et al. (2012) insist that UDL can be applied in low-tech settings:

> UDL is not primarily about technology; it is about pedagogy. The most radical aspect of UDL is not that it raises our expectations about technology, but that it raises our expectations about education. … UDL provides an approach, based on the sciences of learning rather than the sciences of technology, for designing learning environments that have high expectations --- and results --- for all students.

Eigo Note is full of pictures, maps and charts, but these disregard visual impaired children. The "chant" activity is essential, but this disregards hearing impaired children. It should be a globe instead of a map. It could be dolls and models instead of colorful pictures. Instead of CD, it could be DVD providing the role model (e.g. deaf adults signing about English and international activity). In stead of "chanting", motor activity could be effective for all the children.

Neuro science of hearing/visual impairments are not only for technological development but also for pedagogical improvement. Lessons with many visual aids should be supplemented with specific verbal explanation for visual impaired children. This should be accompanied by taking the child through the motions, not just by relying on verbal descriptions of what the child has to do. Physical activities and games or the use and manipulation of concrete objects are effective.

Lessons should have multiple measures, visual to auditory and motor activities. Visual impaired children can not see facial expressions or gestures, therefore the teacher should use physical contact with verbal instruction.

According to S. Goldin-Meadow, hand gestures improve learning not only in signers, but also speakers. Hearing children use spontaneous gestures while they are talking. The same kind of gestures, not sign language, appear in signing children as well (Goldin-Meadow, 2014). In other words, gestures help language acquisition. But these gestures are, and should be, spontaneous, teachers should not force to make them, but encourage to move freely.

Emiliano Ayala et al. (2012) mention that “given the increasing need to create more valid educational accountability systems, the general curriculum must be designed from the outset to be accessible to all the students; this will eliminate or significantly reduce the myriad modifications that currently exist” (p.135).

Because it is difficult for those who have no impairments to understand cognitions of children with hearing/visual impairments, teachers with hearing/visual impairments should be involved “from the outset.” This does not necessarily mean the teacher with the same impairments as children understands the difficulties. They rather understand the advantages of loss of one sense and how to develop other senses.

Teachers with the same cognitive style are ideal for teaching, developing teaching materials/methods and as role models.

Since there are not many teachers with hearing/visual impairments, on-line teaching or short term intensive classes must be efficient. It is preferable to have teachers, teaching assistants, or supporters with hearing/visual impairments in school. After-school-lessons by teachers or college students with the same impairment are effective (Saito 2013).

Conclusion

In this article the newest findings about cognition of children with hearing/visual impairments are introduced, and their applicability to foreign language teaching, especially elementary school English has been discussed. In chapter I, the most recent cognitive assessments and experiments were reviewed. In chapter II, the English teaching materials provided by MEXT were examined, which could be improved, by making the best use of the cognitive characteristics of hearing/visual impaired children and ICT as well. The teachers should not adhere the same modalities as other children use, such as *listening* comprehension, but they should understand there are people who listen through eyes, or see through ears. In chapter III, the applicability of neuro-science for ICT and unplugged teaching method were discussed. They are applicable to every child, whether he/she has impairments or not, because every child has his/her own cognitive tendency and characteristics (Saito 2009). In addition, UDL cannot be realized without involvement of teachers and supporters with the same cognitions as the children with hearing/visual impairments, because educators and researchers with no impairments can notice the special cognitive ability caused by the “loss” of some perception, but cannot have actual feeling. Also, it is difficult to obtain sufficient sample sizes to evaluate the effect of teaching materials/methods.

The forefront of UDL such as CAST has not necessarily caught up with the newest neurological discoveries mentioned chapter I. But in the near future, the impairments will be taken advantage of, not be supplemented, to develop language teaching materials/methods, which is the next step of this research.

(This work is supported by JSPS KAKENHI Grant-in Aid for Scientific Research (B) 243201080001.)

Bibliography

Anderson, E.S., et al. (1993), "The Impact of Input: Language Acquisition in the Visually Impaired," *First Language* 13:23-49.

Anderson, E.S., et al. (1984), "Blind Children's Language: Resolving Some Differences," *Journal of Child language*, 11:645-664.

Ayala, Emiliano et al. (2012), "Preparing Teachers to Implement Universal Design for Learning," Tracey E. Hall et al. (eds), *Universal Design for Learning in the Classroom*, The Guilford Publications, Inc, New York, USA, pp.135-152.

Bavelier, Daphne et al. (2001), "Impact of Early Deafness and Early Exposure to Sign Language on the Cerebral Organization for Motion Process", *The Journal of Neuroscience*, 21(22):8931-8942.

Bedny, M. et al. (2010), "Sensitive Period for a Multi-modal Response in Human MT/MST," *Current Biology*, 14 October, 2010 OI: 10.1016/j.cub.2010.09.044

Bhattacharjee, A., et al. (2010), "Vibrotactile Masking Experiments Reveal Accelerated Somatosensory Processing in Congenitally Blind Braille Readers," *Journal of Neuroscience*, 30 (43): 14288

CAST profile mentor, http://www.cast.org/teachingeverystudent /content/mentors/class_ profile_mentor/class_profile_ mentor_3brain.cfm (2014.11.20)

Cattaneo, Zaira & Tomaso Vechi, (2011), *Blind Vision --- The Neuroscience of Visual Impairment*, The MIT Press.

Emmorey, K., (2002), *Language, Cognition, and the Brain: Insights from sign Language Research*, Lawrence Erlbaum, NJ, USA.

Georgetown University Medical Center, Brain Anatomy Differences Between Deaf, Hearing Depend on First Language Learned, http://gumc.georgetown.edu/news /Brain-Anatomy-Differences-Between-Deaf-Hearing-Depend-on-First-Language-Learned (2014.11.20)

Gilley, P. M. (2010), The Influence of a Sensitive Period for Auditory-Visual Integration in Children with Cochlear Implants," *Restorative Neurology and Neuroscience*, 28, 207-218.

Goldin-Meadow, S., (2014), "Widening the Lens: What the Manual Modality Reveals about Language," *learning and cognition, Philosophical Transaction of Royal Society B: Biological Science*, 369.

Gougoux, Frederic, et al. (2004), "Pitch Discrimination in the Early Blind," *Nature*, 430-6997, p.309

Kronenberger W.G. et al. (2014), "Neurocognitive Risk in Children with Cochlear Implants," *Journal of the American Medical Association Otolarybgiigy-Head and Neck Surgery*, 2014-May,757.

Maller, Susan J., and Jeffery P. Braden (2011), "Intellectual Assessment of Deaf People: A Critic Review of Core Concepts and Issues," the *Oxford Handbook of Deaf Studies, Language and Education*, (2nd edition), Oxford University Press, UK, pp.473-485.

Marschark, Marc, et al. (2013), "Are Deaf Students Visual Learners?" *Learning and Individual Differences*, 25, 156-162.

Marschark, M.and L.Wauters (2011), "Cognitive Functioning in Deaf Adults and Children," M. Marschark & P. E. Spencer (eds), *The Oxford Handbook of Deaf Studies, Language and Education*, 2nd edition), Oxford University Press, UK, pp.486-499.

Matsuo, M. and M Sakajiri (2013), "The Development of a Barrier-Free Game Used by Visually Impaired Persons Using Sounds and a Tactile Sense," *National University Corporation Tsukuba University Technology Techno Report,* vol. 21 (1) 77-79.

Meadow-Orlans, K. & Spencer, P & L. Koestel (2004), *The World of Deaf Infants; Longitudinal Study*, Oxford University Press, UK.

Morash, Valerie S. et all., (2014), "Effects of Using Multiple Hands and Fingers on Haptic Performance in Individuals Who are Blind," *Perception*, 43 (6): 569

Nevill, H. J., & D. Bavelier (2001) "Variability of Developmental Plasticity," in J.L. McClelland & R. S. Siegler (eds.) *Mechanisms of Cognitive Development; Behavioral and Neural Perspectives*, Lawrence, Erlbaum Associates

Publishers, USA. pp.271-301.

Olulade, Olumide A, et al. (2014), "Neuroanatomical Profiles of Deafness in the Context of Naïve Language Experience," *The Journal of Neuroscience*, Vol. 30, 16:5613

Perky Duck: Duxbury Braille Translator for Windows (DBT 11.2 SR4) http://www. duxburysystems.com/products.asp (2014.11.20)

Renier, Laurent A., et al, (2010), "Preserved Funtional Specializaion for Spatial Processing in Middle Occipital Gyrus of the Early Blind", *Neuron*, 68 (1): 138-148.

Röder, Brigitte & Rösler, Frank, (2003), "Memory for Environmental Sounds in Sighted, Congenitally Blind and Late Blind Adults: Evidence for Cross-modal Compensation", *International Journal of Psychophysiology*, 50-1, 27-39.

Rouger, J. et al. (2008) "McGurk effects in Cochlear-Implanted Deaf Subjects," Brain Research, 1188, 87-99.

Rose, David H. et al. (2012), "Universal Design for Learning 'Unplugged' Application in Low-Tech Settings," Tracey E. Hall et al. (eds), *Universal Design for Learning in the Classroom*, The Guilford Publications, Inc, New York, USA, pp.120-134.

Saito, Kurumi (2000), "The Relationship between the Visual Perception and the Linguistic Ability of Student's Signers," *Study Report on Japan College of Social Work*, 47,145-162.

__________(2009), "English Teaching Software for University Students Aiming at Barrier-Free Communication," *Journal of Liberal and General Education Society of Japan*, 59, 154-161.

Seki, Keiko, et al., (2012), "Shogaku-bu ni okeru gaikokugokatudou no torikumi" (Foreign Language teaching in deaf elementary school) http://www.deaf-s.tsukuba.ac.jp/repository/Bulletin2012/kiyou2012-3 (2014.11.20)

Sharma, Anu & Teresa Mitchell, (2013), "The Impact of Deafness on the Human Central Auditory and Visual Systems", *Deafness*, Vol. 9-2; 1-9

Spencer, P. & M. Marschark (2010), *Evidence-Based Practice in Educating Deaf and Hard-of-hearing Students*, Oxford University Press, UK.

Stevensa, A.A. & K.Weaver (2005) "Auditory Perceptual Consolidation in Early-onset Blindness," *Neuropsychologia*, vol.43, Iss.13, 1901-1910.

Striem-Amit, et al. (2014), "Visual Cortex Extrastriate Body-Selective Area Activation in Congenitally Blind People 'Seeing' by Using Sounds", *Current Biology*, 2014,02,010.

STS cl (Space Telescope Science Institute) (2014), "Electronic Bool for students with visual impairments reached for the stars", ScienceDaily, Jan. 2014. (www.sciencedaily.com/releases/2014/01/140109124943.html)

Thaler, Lore, et al. (2011), "Neural Correlates of Natural Human Echolocation in Early and Late Blind Echolocation Experts," PLoS ONE, 6 (5): e20162.

Voss, P. et al. (2011), "Relevance of Spectral Cues for Auditory Spatial Processing in the Occipital Cortex of the Blind", Frontiers in Psychology, Mar 28th 2011 (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3110881/)

Voss, Patrice & Robert J. Zatorre, (2012), "Occipital Cortical Thickness Predicts Performance on Pitche and Musical Tasks in Blind Individuals," Cerebral Cortex, vol 22 -11. 2455-2464

Weeks, Robert et al. (2000), "A Positron Emission Tomographic Study of Auditory Localization in the Congenitally Blind, *The Journal of Neuroscience*, 20 (7), 2664-2672.

Wong, Michael et al. (2011), "Tactile Spatial Acuity Enhancement in Blindness: Evidence for Experience --- Dependent Mechanism," Journal of Neuroscience 31(19), 7028-7037.

Wong, Michael, Ryan M. Peters1, and Daniel Goldreich, (2013), "A Physical Constraint on Perceptual Learning: Tactile Spatial Acuity Improves with Training to a Limit Set by Finger Size," The Journal of Neuroscience, 33(22): 9345-9352.