WORKING MEMORY IN DEAF PEOPLE

Introduction

Before discussing the details of working memory in deaf people, it is better to understand important terms we are using in the platform of eLearning teacher training programme for literacy learning and teaching in Sub-Saharan Africa (eTALE). These are *working memory* and *deafness* as well as *deaf.*

Working memory

Working memory (WM) refers to the human capacity to encode, store, manipulate, and recall information [(1)]. WM is a cognitive system that strongly relates to a person's ability to reason with novel information and direct attention to goal-relevant information [(2)]. Therefore, WM can be defined as the ability to gather and keep information and to retrieve it at the moment it is needed. WM is said to have three storage components, according to the WM model proposed by Baddeley, Allen and Hitch [(3)]. Their model stipulates that WM involves the phonological loop, which stores auditory information; the visuospatial sketchpad that stores visual and kinaesthetic information; and the episodic buffer.

WM is said to be directly affected by language development. Hence, children with developmental language impairments are often reported to show difficulties with WM [(4)]. Also, according to Baddeley and Hitch [(5)], WM plays an important role in supporting a whole range of complex everyday cognitive activities, including reasoning, language comprehension, long-term learning, and mental arithmetic. The arguments above are in line with the findings of Marshall et al. [(6)], which indicate vocabulary as a significant, unique predictor of performance on WM tasks.

Deafness

Before explaining what deafness is, it is wise to go through the general term that embraces it: hearing impairment. Hearing impairment is a general term used to describe all levels of hearing loss, ranging from mild to profound. Therefore, it can either be defined as partial inability/ability to

hear sound waves through normal hearing mechanisms or total inability to hear sound waves, even when using amplification devices.

A person with partial hearing inability/ability is technically and medically known as hard of hearing, while a person with total inability is known as a deaf person. Thus, deafness is the total inability to hear sound waves through hearing mechanisms, even with the use of amplification devices [(7)].

Types of deafness

There are different types of deafness depending on the factors being considered when categorising them. Within this document, the language development factor has been considered in categorising types of deafness. Basing on this factor, there are three types of deafness:

1. prelingual hearing impairment, which occurs before acquiring the first language.
2. perilingual hearing impairment, which is acquired while developing the first language.
3. post-lingual hearing impairment, which is acquired after developing the first language.

Deaf people in these three categories differ in various issues due to their language background and family. The type of family contributes significantly to the development of an individual. For instance, prelingual deaf people of hearing parents who don't know sign language have different experiences from those of prelingual deaf people of deaf parents who use sign language. Moreover, post-lingual deaf people from hearing families have different experiences than those of post-lingual deaf people from deaf families. The issue that makes the difference is the language ability and type of language being used by parents of deaf children (spoken or sign language). Therefore, it is obvious that both expressive and receptive language ability have an influence on learning and the cognitive development of an individual.

WM among deaf people

Regardless of their inability to perceive sound waves, deaf children have the same right to education as their hearing peers. Since they need to learn different content that will enable them to be independent later in their life, it is clear that memory plays an important role in learning. WM capacity is essential for an individual to master the content, a fact that has made deaf children be labeled as slow learners.

Hearing children are said to have higher WM capacity than deaf children due to the advantages of early language development and incidental learning [1]. Contrary to hearing peers, most deaf children have poor language abilities and lack incidental learning. Deafness also affects children's concentration ability because it makes them dependant on their eyes for gathering information, and when their eyes get tired, they have difficulties following along. Furthermore, deaf children can't concentrate and follow information presented through lengthy texts.

Too much information and too much information at a time may sometimes lead to WM overload. Because deaf people depend on one sense organ to capture information, their brain is overworked as it makes sure to interpret every piece of captured information. When this happens, deaf children are likely to forget most of the things they have learnt at that time. Hence, they are visual learners. They remember and understand information that has a lot of visual representations and that is related to the visuospatial sketchpad. Deafness and use of sign language may result in greater reliance not only on visual but also episodic coding related to the episodic buffer, as compared to what is typical for hearing children [1].

WM and sign language

Sign language is a manual language that is transmitted visually, in contrast to oral language which is transmitted audio-acoustically. Thus, sign language, being an independent language, contributes to the development of WM ability. Its effectiveness depends on a number of factors.

The development of an individual's WM with the support of sign language depends on the individual's signing fluency and surrounding community. If the deaf person is a fluent signer and the community around him/her is fluent in sign language, he/she will have higher WM skills. But if the deaf person is not fluent and competent in either sign language or spoken language and the community around him/her is only competent in spoken language, he/she will have poor WM. Problems in WM (especially in the visuospatial sketchpad and the episodic buffer) may also sometimes hinder the development of sign language. However, it is interesting that, although signers and speakers may differ in the extent to which they call upon any given subsystem, the available evidence indicates that their ultimate attainment is equal [1]. Sign language experience

also produces adaptations to visuospatial WM. Many visuospatial functions are enhanced among deaf (and hearing) native signers, probably as a result of the spatial properties of the language [8].

Sign language is a true language form, and it is represented in WM via mechanisms analogous to those for speech. Early exposure to sign language gives rise to cognitive adaptations that permit the internal presentation of signs [8]. The age in which a person acquires deafness may also determine the impact of sign language on the development of WM. If a person becomes deaf after acquiring spoken language, for instance at the age of 18, and he/she fails to be fluent or competent in sign language, his/her WM might not be much affected. But if an individual becomes deaf before acquiring spoken language and he/she fails to become fluent/competent in sign language, he/she will be much affected in his/her WM development. The above arguments are in line with the findings of Marschark, et.al. [9], who argue that deaf individuals who are native signers have been found to score higher on visuospatial memory tasks than on verbal-sequential tasks and higher on some visuospatial tasks than hearing non-signers.

WM and reading abilities among deaf children

Reading is defined as the process of looking at a series of written symbols and getting meaning from them [10]. It is also said that when reading, we use our eyes to receive written symbols (letters, punctuation marks, and spaces) and our brain to convert them into words, sentences, and paragraphs that communicate something to us. Thus, reading can either be silent (in our head) or aloud. Learning to read is often an area of difficulty for deaf children. Success in learning to read is moderated by (among other factors) phonological awareness and general language competence. Phonological awareness is correlated with better speech articulation and lip-reading skills. Based on research, we also know that general language competence is usually greater for children raised in fluent signing environments [8].

Hearing children learn to read by linking letters to sounds, something that is difficult for deaf children. Deaf and hard of hearing children use a different approach in learning reading skills because, with little or no knowledge of spoken language, they cannot make this connection. Deaf and hard of hearing children first need to develop their sign language skills, after which teachers can start teaching written words. Written words (and eventually sentences and texts) have no

meaning for deaf and hard of hearing learners until they are linked to sign language that the children already know [11].

Therefore, pre-lingual deaf and hard of hearing children need to understand the world around them first, in order to develop reading comprehension. This means that they need to have a lot of vocabulary items and understand their meaning. Fluency in reading requires deaf and hard of hearing children to have a strong ability for connecting written words to their meaning, which in turn requires a high WM capacity. This is supported by Daneman and Green (12), who argue that individuals who score high on vocabulary tests tend to score high on WM span tasks and also do the same on reading comprehension tasks.

How to improve WM for deaf learners

To improve deaf learners' WM capacity, teachers need to be creative. The WM of deaf children can be improved through the use of a lot of visualisation techniques like mind maps, word spiders, ladders, Frayer's model. (See figure 1)

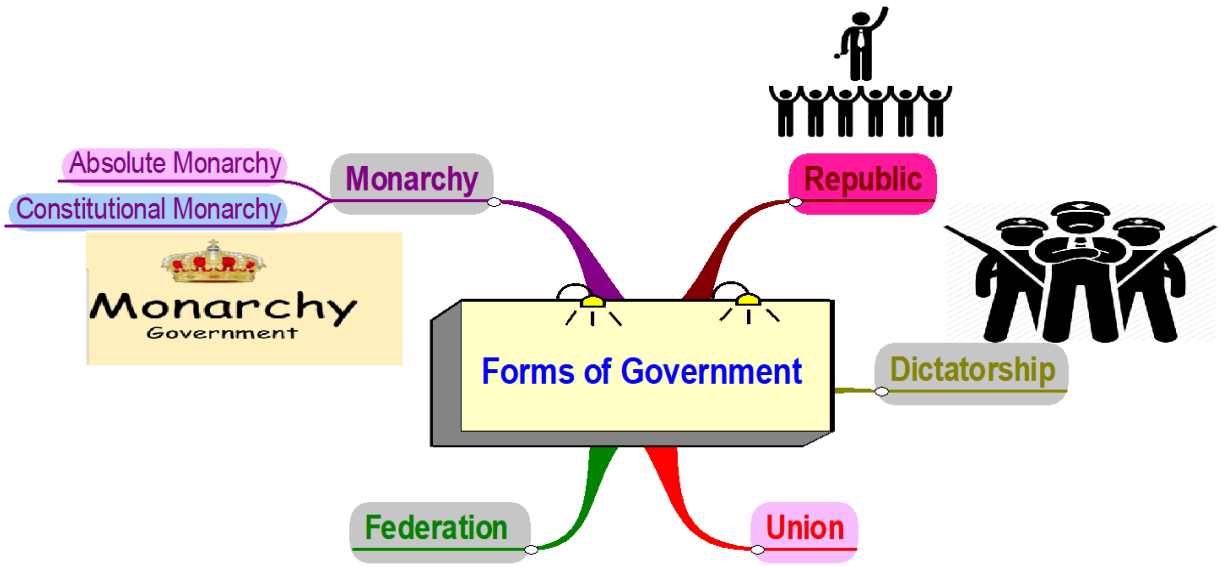

Figure 1: Mind map visualising forms of governments

In addition, texts need to be summarised to make sure that only important information is presented to deaf learners. Summaries can be presented visually using short sentences to limit the amount of information that needs to be stored. Figure 2 provides an example.

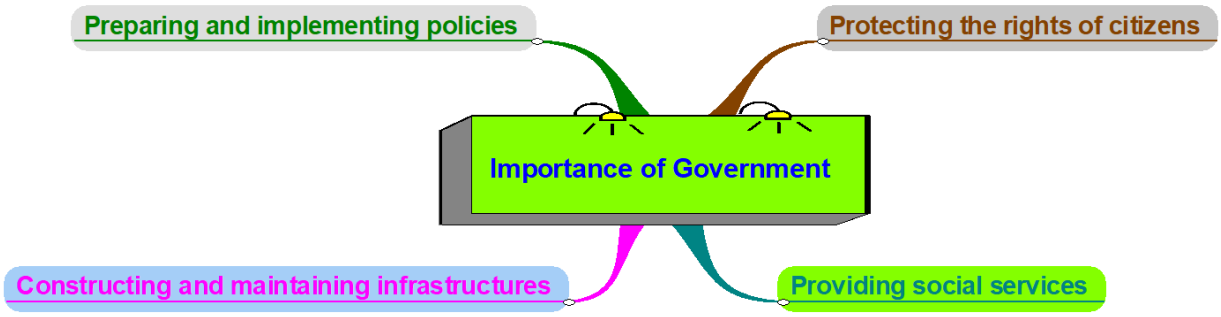

Figure 2: Mind map visualising importances of government

Finally, teachers should break lessons into short learning sessions accompanied with learning games for reinforcing learned content. Apart from that, WM for deaf learners can be improved through memory aids like charts on the walls, regular repetition of information, memory games, and computer and ICT training.

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