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Content analysis of memory and memory-related research studies on children with hearing loss

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Memory plays a profound role in explaining language development, academic learning, and learning disabilities. Even though there is a large body of research on language development, literacy skills, other academic skills, and intellectual characteristics of children with hearing loss, there is no holistic study on their memory processes. Accordingly, the aim of this study is to examine memory-related research on children with hearing loss (CHL). In order to distill methodological and topical trends of those studies so as to unfold relevant research needs. In this research, content analysis method was used to analyze 25 quantitative-empirical studies on memory of children below 18 years. Majority of the research studies grouped normal-hearing children as the norm group. Participants with hearing loss were quite heterogeneous in nature. Causal-comparative and correlational designs were jointly used most frequently as the research model, and assessment was based on multi-measure paradigms. Noteworthy popular topical trends include memory of children using verbal language and cochlear implants; the relation of memory to language development and literacy skills, temporary memory processes, and memory of children attending inclusive classes. A significant conclusion of the current study is that topical trends filtered from the international literature indicate the research need of our country. Furthermore, results of the analysis revealed that taking memory processes into account, especially during the assessment of hard-of-hearing children may contribute drastically to the holistic nature of assessment.

Key words: Hearing loss, children with hearing loss, deaf children, cognition, memory, memory-associated processes, content analysis.

INTRODUCTION

The nature, development and functions of memory, its relations with other cognitive processes, including academic or non-academic skills have been assessed and tested in typically developing children to enhance the capacity of their memory (Spencer-Smith and Klinghberg, 2015). On the contrary, memory studies conducted with individuals with special needs other than autism spectrum disorders are too scarce to predict a pattern or make

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generalizations (Alloway and Gathercole, 2006).

Regarding research on disability groups, those conducted with individuals having visual and hearing impairment generally follow a rather different path than others. Having sensory bases, both visual and hearing losses are not the same as other disabilities. Overall perception of the relation between memory and either visual or hearing loss accepts that there are some kind of sensory compensation mechanism for these individuals. In other words, it is generally believed that individuals with visual impairment happen to hone better auditory skills and those with hearing loss are considered to have more developed visual skills than normally developing peers in order to compensate for the relevant loss. Although there are some studies supporting this view for visually impaired individuals (Melzer et al., 2011), there is no evidence to generalize this perception for people who are hard of hearing. Therefore, one of the reasons for designing memory studies of individuals with hearing loss is the endeavor to identify trends in the validity of sensory compensation approaches (Parasnis et al., 1996).

Memory studies of children with hearing loss (CHL)

Memory studies of individuals with hearing loss are multi-faceted and transcend sensory compensation. The question, “How does auditory withdrawal influence an individual’s cognitive processes?” still remains to be answered. As Braden (1994) contended, at this point, the deaf turn out to be natural participants of a natural experiment. Parallel with this opinion, some studies moved from the basic scientific axis and focused on the relation between the problems of hearing sense and capacity and function of memory (Parasnis et al., 1996).

A larger group of studies that are more practical than the first group examined the relation between memory capacity and language skills, academic skills, and other cognitive processes in CHL. Accordingly, academic skills investigated include reading, writing, and math skills. Language skills involve speech perception and production, learning of new words, and development of vocabulary and grammar. While, intelligence, comprehension, reasoning, metacognition, visual and auditory discrimination and phonological awareness comprise cognitive processes (Marschark and Hauser, 2008). Obviously, the main purpose of these research projects is not to understand the nature of CHL memory, but to determine the role of memory in the development of their academic and language skills.

Although hearing loss presents a natural experimental setting for researchers, working with this group still has some crucial difficulties. The first to note is that this group of individuals is more heterogeneous in nature than both normally developing peers and those with other special needs. A series of demographic, audiological, and educational characteristics with potential influence on both the capacity and functionality of memory in children lead to profound individual differences among members of this group (Marschark, 2006). For instance, the following issues vary across children: demographic features such as age at onset, diagnosis, instrumentation, and cochlear implantation; audiological characteristics such as level of hearing, type of auditory technology used, and type and severity of hearing loss; and educational qualities such as the setting, primary communication mode, receiving of early special education services, and pre-schooling. All of these sources of individual differences mandate strict control during memory studies, which is not easy, as in other research endeavors. Thus, the participants in such studies must be well defined (Marschark, 2006).

The above difficulties also bring out another problem regarding measurement tools. Due to the heterogeneous nature of CHL, there are several controversial measurement approaches such as following general or specific norms, employing standard or non-standard tools, and administering the procedure in sign or verbal language (Braden, 2001).

Problem

Diagnosis and treatment of individuals with hearing loss have been developing rapidly due to technological advances (Marschark and Spencer, 2006; Miller, 2015). Moreover, debates still continue about cognitive development and sensory withdrawal of children (Khan et al., 2005; Mayberry, 2002). Literacy skills of hard-of-hearing children are the most frequently studied topics, followed by intelligence and memory research (Marschark et al., 2009). Although the existing literature hosts a vast amount of comprehensive assessment research, such as meta-analysis and content analysis of empirical studies focusing on literacy skills (Marschark et al., 2009) and intellectual characteristics (Vernon, 1968/2005) of CHL, no holistic research evaluating other studies on memory processes had been detected. Furthermore, the fact that children are heterogeneous population leads to the employment of different scientific methods generally and the use of other measurement tools specifically. This research is considered important since it will help to determine future research needs and methodological requirements via scrutinizing the measurement tools, the processes associated with memory, memory types under focus, and the properties of the samples studied thus far in the literature. In Turkey, very few studies have examined the features of memory and the relation between memory and academic and language skills in CHL (Doğan et al., 2013). Therefore, this study is a valuable effort to enrich the number of limited studies and to provide a framework of the topic for

researchers in our country. Moreover, this research has the potential to integrate memory processes into cognitive assessment procedures already in use. Finally, it is hoped that this study will find a key place in the literature since it will help researchers and practitioners to clearly see the general research trends by depicting different phases that relevant research efforts have gone through over time.

Purpose

The purpose of this study is to analyze international studies associated with memory in CHL to determine topical and methodological properties and to identify research trends and relevant research needs.

Accordingly, the following research questions were answered:

1. What are the demographic, audiological, and educational characteristics of children who participated in these studies?
2. What are the research models employed in these studies?
3. What are the memory types examined in these studies? What are the measurement tools utilized to determine the memory types examined in these studies?
4. What are the processes and skills associated with the memory types examined in these studies? What are the measurement tools utilized to determine the processes associated with the memory examined?
5. What are the aims of these studies?
6. What are the major findings of these studies?

METHODS

Research design

Adopting a descriptive model to analyze studies focusing on memory and related processes in CHL, this research employed content analysis method for classifying similar data by organizing them clearly to make relevant interpretations (Yıldırım and Şimşek, 2014). Not based solely on one paradigm, content analysis involves both quantitative and qualitative elements; the former involves the use of digital descriptions while the latter involves giving a detailed investigation and discussion of the topic at hand (Merriam, 2001). In accordance with Merriam's statement, our study has both quantitative and qualitative dimensions. Based on this research design, studies focusing on memory and related processes in children have been filtered in accordance with a set of specific criteria. Findings of the study were identified via analysis of data within specific categories, and these findings were examined and discussed in detail.

Selection of research studies

A purposive sampling method, criterion sampling, was utilized in order to determine the research span (Yıldırım and Şimşek, 2014). Accordingly, the criteria adopted during the selection of documents in the present study are as follows: (a) The study must be empirical, containing quantitative data; (b) The study must have been conducted between 2000 and 2015; (c) The study's focus must be either memory or memory-related processes in children; and (d) The participants must be children below 18 years.

Based on these preliminary criteria, electronic bulk databases were scanned online. During this scan, studies in which the following keywords co-existed were filtered: Hearing loss, hearing impairment, hearing disability, deafness, cochlear implant, children, adolescents, teenagers, and memory.

Databases used in this study are Academic Search Complete, Catalogue of Anadolu University, Cambridge Journals Onli-ne, Dissertation Abstracts International, EBSCOhost, Elsevier, ERIC, Oxford Journals Online, PsycINFO, PubMed, SocINDEX with Full Text, Springer LINK Contemporary, Taylor and Francis Journals, Wiley Black, and Wilson Select Plus. The Proquest Dissertations and Theses database were also scanned to examine the references of related theses through a footnote-chasing technique. Both researchers compiled the studies they identified in accordance with preliminary criteria. The scan revealed 75 research studies conducted on children's memory since 2000. The researchers independently carried out a further filter analysis of these studies to identify those conducted with participants aged 18 or below and those designed empirically. These results were compared, and a final 25 studies meeting all the criteria were selected for analysis. Table 1 depicts the distribution of these studies across years.

In Table 1, the median year for all the research is 2007. Nine studies (36%) were published before 2007, and the remaining 16 (64%) were published after 2007. In other words, two-thirds of the research on memory of CHL were conducted recently.

Data analysis

All the documents within the scope of this research were analyzed via content analysis. In content analysis, the researcher develops categories related to the research topic, and counts the words, sentences, or pictures that fall into these categories from the research data set (Silverman, 2001). In this study, two tables were created one for participants' characteristics and the other for the categories in order to see the data analysis procedure fully. Subsequently, separate tables and figures were developed based on each category.

The following six categories were identified during the data analysis phase:

1. Demographic characteristics of the participants (the number, gender, mean age, and age range; mean age and age range at diagnosis; mean age and age range of implant insertion/mean age and age range of implant use for all participants with and without hearing loss), audiological characteristics (average hearing level/severity of hearing loss, hearing aid technology), and educational characteristics (primary communication mode, educational setting).
2. Research models
3. Memory type under focus and measurement tools
4. Processes and skills associated with memory and measurement tools
5. Main research aim(s)
6. Main research finding(s).

An evaluation form, called Article Description Form, consisting of two main parts, was developed in order to analyze the findings comprehensively. The first part of this form is allocated to demographic, audiological, and educational characteristics. The second part is developed to examine research models, memory

Table 1. Distribution of accessed studies across years.

Year	Frequency (n)	Percentage
2000	2	8
2001	1	4
2002	1	4
2003	2	8
2004	3	12
2007	2	8
2008	1	4
2010	1	4
2011	3	12
2012	1	4
2013	4	16
2014	2	8
2015	2	8
Total	**25**	**100**

types under focus, measurement tools for memory and processes and skills associated with memory, measurement tools for processes and skills associated with memory, study aims, and major research findings. The category, "aim of the study" was included at the end of the form because the authors wanted to clearly show the relation between aim and findings. All of these parts comprising a meaningful whole were named (that is, coded) by the researchers (Neuman, 2012). Each researcher did this coding for each document separately based on these categories.

Interrater reliability concerning the coding by two researchers was calculated via agreement rate formula, which is "P (agreement rate) = [Na (amount of agreement)] / [Na (amount of agreement) + Nd (amount of disagreement)] × 100." Interrater reliability was found to be 92%, which is quite high for qualitative studies (Miles and Huberman, 1994). Where there was no interrater agreement, the researchers re-assessed the coding to establish agreement.

FINDINGS

The findings of this study aimed at analyzing memory-based studies of CHL are presented parallel to the research questions. Within this scope, the participants' characteristics are analyzed first, and then the other research questions are addressed.

Analysis of participants' characteristics

CHL are extremely heterogeneous. Therefore, it is crucial to classify their characteristics properly (Marschark et al., 2009). Hence, the characteristics of the CHL who participated in the selected studies were analyzed under three sub-categories: Demographic, audiological, and educational. The number of all participants and children, gender, age, age of diagnosis, and age of implantation/duration of implant use of the participants with hearing loss were examined under demographic features, whereas level of hearing/severity of hearing loss and hearing technology were addressed under audiological features. Lastly, primary communication mode and educational setting were investigated under educational features (Doğan, 2011). Within this classification system, details regarding the participants' characteristics are shown in Table 2.

Demographic characteristics

As shown in Table 2, 1195 of all the participants (*N* = 1643), including the comparison groups built in 25 studies, were CHL. The minimum and maximum numbers of participants in these studies were 6 and 176, respectively. The average number of participants in each study was 48. In many of the studies, the children were paired with their peers having the same gender and age, but normal hearing. Accordingly, it can be said that the distribution of CHL and normally hearing children was balanced. When the participants with hearing loss are examined in terms of gender, the rate is similar. Although no information about gender is reported in six of these studies, it was indicated that 359 and 351 of the participants were females and males in the other studies, respectively.

One of the criteria employed for the selection of the documents analyzed in this study is participants must be 18 years and below. In five studies, the mean age of the participants with a 20% hearing loss was not specified, while it was 9 years and 7 months for those with 80% hearing loss in the other 20 studies. It is understood that the youngest participant was 4 years old and the eldest was 18 years and 6 months old. In terms of memory and language development in CHL, age at diagnosis is another significant variable. In approximately half of the studies (44%), there is no information about age at

Table 2. Characteristics of participants with hearing loss.

S/N	Reference	Demographic characteristics					Audiological Characteristics		Educational characteristics	
		Total N [HL Participant N]	Gender of HL Participant	Age of HL Participants [Range]	Age at diagnosis [Range]	Mean age at CI/ Duration of CI Use	Degree of HL	Hearing technology	Primary communication mode	Educational Setting
1	Cleary et al. (2000)	[49]	-	9;2 [5;3-16;5]	0;4 [0-3]	4;4/4;8	Profound	CI	27 OC, 22 TC	-
2	Pisoni and Geers (2000)	[43]	-	[8-9;11]	-	-/5;5	-	CI	½ OC, ½ TC	-
3	Cleary et al. (2001)	125 [81]	19 F, 25 M	8;10 [7;11-9;11]	0;3 [0-3]	-/5;6	-	CI	OC	Inclusion
4	Dawson et al. (2002)	48 [24]	12 F, 12 M	[5-11]	0;4 [0-2;3]	3;6/4;6	-	CI	17 OC, 7 TC	Inclusion
5	Burkholder and Pisoni (2003)	73 [37]	12 F, 25 M	8;7 [8-9]	0;2	3;04/5;66	Profound	CI	22 OC, 15 TC	Inclusion
6	Pisoni and Cleary (2003)	221 [176]	-	[8-9]	-	- /3;6	Severe, profound	CI	OC or TC	Inclusion
7	Hansson et al. (2004)	83 [18]	10 F, 8 M	10;10 [9;1-13;3]	4;2 [1;3-7;5]	-	Mild, moderate	HA	OC	Inclusion, SCHL
8	Harris and Moreno (2004)	179 [62]	-	[8-14]	-	-	Severe, profound	-	OC and TC	-
9	Willstedt et al. (2004)	[15]	9 F, 6 M	7;7 [5;4-11;5]	Newborn	3;1/4;1	-	CI	SL	Inclusion
10	Alamargot et al. (2007)	30 [15]	-	13;8 [11;6-17]	Prelingual	-	Profound	-	SL	Inclusion
11	Asker-Arnason et al. (2007)	32 [16]	10 F, 6 M	10 [7;2-13;4]	< 3	3;8/6;6	Severe, profound	CI	OC	Inclusion
12	Wass et al. (2008)	75 [19]	11 F, 8 M	9 [5;7-13;4]	1;6	3;4 /5;5	-	CI	OC	Inclusion, SCHL, SD
13	Cockcroft et al. (2010)	39 [24]	15 F, 9 M	8 [4-11]	-	-	-	-	SL	Inclusion
14	Engel-Yeger et al. (2011)	40 [20]	6 F, 14 M	8;8 [8-10]	-	4;3-6;9/-	-	CI	OC and TC	ICHL
15	Kronenberger et al. (2011)	[9]	6 F, 3 M	10;2 [7-15]	Newborn	1;8/8;6	Profound	CI	OC	Inclusion
16	Stiles et al. (2011)	40 [16]	10 F, 6 M	7;8 [6-9]	-	-	Moderate, severe	HA	OC	Inclusion
17	Lopez-Crespo et al. (2012)	50 [30]	-	11;3	-	-	-	12 CI	10 OC, 9 SL, 11 Bilingual	Inclusion
18	Doğan et al. (2013)	223 [120]	70 F, 50 M	10;10 [7-15]	2;5	5;6/5;4	profound	77 HA, 43 CI	OC	Inclusion, SCHL, URC
19	Geers et al. (2013)	158 [112]	59 F, 53 M	16;8 [15-18;6]	-	-/13;4	Severe, profound	CI	-	Inclusion
20	Harris et al. (2013)	[66]	32 F, 34 M	7;6 [6;0-11;6]	0;3 [0-3]	3;8/3;7	Profound	CI	43 OC, 23 TC	Inclusion
21	Nittrouer et al. (2013)	172 [50]	26 F, 24 M	7;6 [6-8;5]	%80<1, %20< 2	1;10/6;9	-	CI	OC	Inclusion
22	Nunes et al. (2014)	[150]	33 F, 44 M	8;5 [5-11]	-	-	-	48 CI, 102 HA	SL and OC	-
23	Willis et al. (2014)	[6]	2 F, 4 M	10;5 [8-15]	-	< 2;6/-	Severe, profound	3 CI, 3 HA	OC	Inclusion, SCHL
24	Bharadwaj et al. (2015)	[10]	6 F, 4 M	[7-11]	-	3-4;6/-	Severe, profound	CI	OC	Inclusion
25	Marshall et al. (2015)	55 [27]	11 F, 16 M	9;2 [6-11]	Newborn	-	Severe, profound	9 CI, 16 HA	18SL, 3OC 6 SL + OC	-
	Total	1643 [1195]	359 F, 351 M	9;7 [4-18;6]	1;2 [0-7;5]	3;3/6;2	94 [30-120.1]	842 CI, 232 HA	OC>TC>SL> Bilingual	%70 Inclusion, %10 SD + ICHL+SCHL+URC

CI, Cochlear implant; dBHL, decibel hearing level; F, female; HA, Hearing Device; ICHL, Institute for Children with Hearing Loss; M, Male; N, Number of Participants; OC, Oral Communication; SCHL, School for Children with Hearing Loss; SD, School for the Deaf; SL, Sign Language; TC, Total Communication; URC, University Research Center.

diagnosis. On the other hand, in eight studies (32%), mean age at diagnosis was 1 year and 2 months. There are seven studies (27%) indicating that the age at diagnosis was at least 0 or unborn. The age at diagnosis range is from 0 to 13 years and 3 months.

Implant age is as important as age and age at diagnosis in terms of memory and language development in children. To be implanted, the participant's age should be 3 years and 3 months on average. It is determined that the implant age was at least 1 year and 4 months and mostly 10 across all the studies. In some studies, no information was reported about mean age and age range of participants (28%). The participants' duration of using implants was approximately 6 years 2 months. According to the studies, the duration of implant use was a minimum of 1 to a maximum of 11 years and 7 months.

Audiological characteristics

Regarding audiological characteristics in some of the research (32%), the level of hearing loss for the participants was specified as moderately severe or severe. The minimum hearing level was 30 dBHL, and the maximum level was 120.1 dBHL (Cleary et al., 2000). In many of the studies (40%), no information was provided about the hearing level.

Considering the hearing technology based on hearing level and hearing loss, most of the participants with hearing loss (80%) were cochlear implant users while some of them (15%) used conventional hearing aids.

Educational characteristics

The primary communication mode of the participants in 21 studies (84%) was verbal, followed by total communication, sign language, and bilingual communication modes. In Geers et al. (2013), where the relation between memory and reading skills was examined, there was no explanation of primary communication mode.

Early diagnosis, hearing technology, and primary communication mode determine the educational setting for children. In these studies, the educational setting was inclusive classes for most of the participants (70%). It was stated that the educational settings of some participants in these studies (20%) were schools for the deaf, schools for the hard of hearing, institutes for the hearing impaired, and university research centers for the deaf. However, there was no information about the educational settings of the participants in other studies (20%). All findings apart from the features of the participants are based on the data shown in Table 3.

Research models

The first category in Table 3 includes the models of the studies examined. Figure 1 shows the distribution of these studies across the research models.

One of the criteria for the selection of studies was that target studies must be quantitative-empirical. As shown in Figure 1, 10 (40%) studies were causal-comparative and correlational, five (20%) were experimental, four (16%) were only correlational, three (12%) were only causal-comparative, and the other three studies were descriptive (4%), quasi-experimental (4%), and longitudinal (4%), respectively. So, most of the studies used causal-comparative and correlational models, followed by experimental, correlational, and causal-comparative models.

Memory type and measurement tools

It was observed that most of the studies (80%) focused on one memory type while some of them (20%) focused on more than one memory type. Figure 2 shows the distribution of memory types under focus.

As indicated in Figure 2, most studies focused on working memory. Following working memory are visual working memory (13%), short term memory (STM, 13%), verbal (13%), auditory WM/STM (6%), and meta-memory (3%) types based on stimulus modalities. The measurement tools used to assess memory types are displayed in Table 4 in terms of their psychometric features.

In order to assess the memory types on which these studies focused, one or more tests or tasks were used. Both the same and different measurement tools were employed in these studies. The measurement tools used to assess the performance of memory are classified as standard and non-standard measurement tools. As shown in Table 4, 22 (58%) different types of standard measurement tools and 16 (42%) different types of non-standard measurement tools were used (Table 3).

Processes and skills associated with memory and measurement tools

In eight (32%) of the studies examined, memory was not associated with any skill. On the other hand, in the other 17 (68%) studies, memory was associated with speaking (that is, speech perception, speech production, and articulation rate), language, literacy, grammar, vocabulary (that is, word recognition, receptive vocabulary, learning new words, vocabulary access), and phonological skills.

As can be seen in Figure 3, skills related to word is the skill most frequently associated with memory (28%), followed by speaking (24%), language (21%), reading (18%), writing (3%), grammar (3%), and phonological skills (3%). Measurement tools employed to assess skills associated with memory are depicted in Table 5, as

Table 3. Summary ıdentities of the analyzed research in terms of the determined categories.

No.	Reference	Research method	Memory type [measurement tool]	Memory-Related skills [measurement tool]	Aim	Major finding(s)
1	Cleary et al. (2000)	Correlational	WM [WISC-III Auditory Digit Span-Backward and Forward, Memory Span Game]	Spoken Word Recognition [PBK and LNT], Receptive Vocabulary [PPVT-3]	The role of WM in explaining the variation in word recognition and receptive vocabulary skills of children with CI.	Word recognition, WM and receptive vocabulary are related only when WM tasks were presented in auditory modality.
2	Pisoni and Geers (2000)	Correlational	WM[WISC-III Auditory Digit Span-Backward and Forward]	Speech Perception [WIPI, LNT, BKB, CHIVE], Speech Production [McGarr Sentences], Language [WISC-III Similarities Subtest, TACL], Reading [WWA, PIAT, Rhyme]	The role of WM on speech perception, word recognition, speech production, language and reading tasks.	(1) WM and processing of spoken language are closely related. (2) WM uses speech perception, speech production, language comprehension and reading, and sharing common processing sources with reading.
3	Cleary et al. (2001)	Experimental	WM[WISC-III Digit Span-Backward and Forward, Memory Span Game]	-	Comparing the WM characteristics of children using CI for at least 4 years to normally hearing children.	WM task scores of children using CI are lower than their normally hearing peers. When visual-spatial clues are available, CI users do not use auditory stimuli as effectively as normally hearing ones.
4	Dawson et al. (2002)	C-C and Correlational	Auditory STM [Auditory and Visual Memory Tasks, Nonverbal Intelligence Scale (K-ABC)]	Receptive Language [CELF]	Evaluating the auditory sequential STM of CI users in comparison with normally hearing and determining its relation to receptive language.	(1) No sequential recall problems observed specific to CI users. (2) Visual-spatial memory performance obtained from nonverbal intelligence test is the strongest predictor of receptive language.
5	Burkholder and Pisoni (2003)	C-C and Correlational	WM [WISC-III, Digit Span-Backward and Forward]	Speech Rate [McGarr 7-Syllable Sentences]	Determining the relationship between WM span and speech rate on children with CI using verbal and total communication.	(1) Speech rate of CI users is lower than the normally hearing ones. (2) The relationship between WM performance and speech rate is higher on children using total communication than the ones using oral communication.
6	Pisoni and Cleary (2003)	C-C and Correlational	WM[WISC-III Digit Span-Backward and Forward]	Word Recognition [WIPI, LNT, BKB], Speech Rate [McGarr Sentences]	Investigating the correlations between WM, spoken word recognition and articulation rate of CI users in comparison with the ones with normal hearing.	Strong correlation between verbal WM, spoken word recognition and articulation rate was observed. 20% of variance in spoken word recognition may result from individual differences. Normal hearing group performed better in WM tasks.

Table 3. Cont'd

7	Hansson et. al. (2004)	C-C and Correlational	WM [Phonological STM (NWR ve ND), Complex WM (CLPT)]	Novel Word Learning [Novel Word Learning Test, Phoneme Test, PPVT, TROG, TIPS]	Determining the role of phonological STM and complex WM in novel word learning of CHL and ones with normal hearing.	Complex WM is the predictor of novel word learning of CHL. However, there is no correlation between phonological STM and novel word learning.
8	Harris and Moreno (2004)	C-C and Correlational	Phonological Coding (STM) [STM Span Tasks, Orthographic Awareness Task, Spelling Test]	Reading [BAS II Single-Word Reading Test]	Comparing the STM task performances of deaf children with age-matched normal controls, and the correlation between STM and reading test scores.	(1) The STM task scores of deaf children are similar to the reading age-matched hearing group; (2) For deaf children in older age group, STM is a significant predictor for reading skills.
9	Willstedt Svensson et al. (2004)	Correlational	WM [Complex WM (Sentence Comprehension and Word Recall Task), Phonological STM (NWR and ND)]	Novel Word Learning, Grammar [The Lund Test of Grammar and TROG]	Determining the predictive power of WM on novel word learning and grammar development children with CI.	WM tasks explained 72% of the variance in novel word learning and 82% in grammar development.
10	Alamargot et al. (2007)	C-C and Correlational	WM [Production Span, Phonological and Visual-Spatial Span Tasks]	Writing [Graphomotor Task and Text Production Task]	Comparing compositional performances of deaf and hearing students; investigating the relationships between these and WM capacities of deaf students	(1) No differences found between two groups in terms of planning and graphomotor execution, deaf students made more PI errors; (2) Differences observed in writing and phonological spans, but not in the visuospatial span; (3) Central executive capacity is associated with compositional fluency in deaf students.
11	Asker-Arnason et al. (2007)	C-C and Correlational	WM [Complex WM (SCR, CLPT, CWM), Visual-Spatial WM (VMPT), Phonological STM (NWR and ND)]	Reading [SL 40, SL 60, OS 64], Lexical Skills [WS and SDM]	Comparing the reading levels of CI users and their peers with normal hearing; determining the relation between reading and demographic factors, WM and language skills.	(1) 60% of CI users have the same reading level as the ones with normal hearing do; (2) Whereas complex WM is the predictor of reading, they are not demographical factors; (3) Reading percentages are interrelated with WM.
12	Wass et al. (2008)	C-C and Correlational	WM [Phonological WM (SR and NWR), Complex WM (SCR), Visual-Spatial WM (VMPT)]	Phonological Skills [ND], Lexical Access Skills [PNT, WS, SDM]	Comparing the WM capacity, Lexical access and phonological skills of CI users with the ones with normal hearing; determining the relation between WM, Lexical access and phonological skills.	(1) When compared to the ones with normal hearing, CI users have lower phonological skills, WM and lexical access scores; (2) On CI users, there is no relation between WM and lexical access. WM and phonological skills are correlated.

Table 3. Cont'd.

13	Cockcroft et al. (2010)	C-C	WM [Visual-Spatial WM (AWMA)]	-	Comparing the scores of visual-spatial WM and STM of deaf and hearing children.	In all subtests, the children with normal hearing performed better than the deaf children.
14	Engel-Yeger et al. (2011)	C-C	Memory (CMS) and Meta-memory (CMT-CH)	-	Comparing the CI users and the ones with normal hearing according to their visual memory and meta-memory skills.	CI users had lower scores in visual memory and meta-memory tests when compared to the ones with normal hearing, and they used the context in memorizing less efficient.
15	Kronenberg et al. (2011)	Experimental	WM [WISC-IV Digit Span-Backward and Forward, BRIEF:WM]	Language Skills [WRAML 2-Sentence Repetition]	Determining the effect of WM training program on the development of memory and language skills.	At the end of training program, the development in WM regressed less within 1 month and more within 6 months whereas sentence repetition regressed within 6 months.
16	Stiles et al. (2011)	Experimental	WM [LEAF, McGarr 7-syllable Sentences, WISC-III Forward and Backward Digit Span, Corsi Span, Sequential Encoding Task]	Receptive Vocabulary [PPVT-3]	Investigating the WM problems among CHL and their relation to perceptive vocabulary.	(1) Articulation rates and receptive vocabulary performance of CHL are lower than the ones with normal hearing; (2) In both groups, there is a positive correlation between vocabulary, number series, Corsi span, and articulation.
17	Lopez-Crespo et al. (2012)	Experimental	Visual WM [DMTS]	-	Investigating whether or not CHL using different modes of communication possess superior visual memory.	Groups with HL oral or sign language completed the tasks with high accuracy when compared to the bilingual and normal hearing ones. This shows that there are some problems in visual WM.
18	Doğan et al. (2013)	C-C	WM [Counting Span, Paper Folding Span and Digit Span-Backward], STM	-	Investigating the impact of early intervention on STM and WM capacities of CHL and with normal hearing.	Whereas early intervention made no differences in both memory capacities of normally hearing children, it stimulated a considerable increase on CHL
19	Geers et al. (2013)	C-C and Correlational	WM [WISC-III Backward Digit Span and Complex Reading Span], STM [WISC-III Forward Digit Span]	Reading [TORC], Articulation Rate [McGarr Sentences], Speech Perception [LNT, BKB, CAVET], Language [PPVT]	Comparing the verbal WM and STM performances by teenagers with CI and the ones with normal hearing; determining the contribution of WM and STM to language and reading skills on children with CI.	(1) CI users had the similar/higher scores as the ones with hearing did whereas they got lower scores in phonological STM than the ones with normal hearing; (2) Speech perception, articulation rate, digit-span and reading span all explained 43% of variance in language skills; articulation rate and reading span both explained 34% of variance in reading skills.

Table 3. Cont'd.

20	Harris et al. (2013)	Longitudinal	Verbal STM [WISC-III Digit Span-Forward], Verbal WM [WISC-III Digit Span-Backward]	Speech Perception and Language [PBK, HINT-C, PPVT-3-4, CELF-3]	Comparing the WM/STMs of CI users and the ones with normal hearing. Determining the contributions of WM/STMs to speaking and language skills of CI users.	(1) The verbal STM and WM scores of CI users were one standard deviation below those of normally hearing peers; (2)Verbal STM/WM scores preliminarily obtained by CI users may explain long-term language skills.
21	Nittrouer et al. (2013)	Experimental	Verbal WM [Serial-Recall Task, Rhyming and Non-rhyming Nouns]	-	Investigating the measurability of WM dimensions by a single task and the proficiency level of CI users in these dimensions.	Storing and processing might be measured by a single task, and CI users are competent in storing but not in processing.
22	Nunes et al. (2014)	Quasi-experimental	WM [WMTB-C]	-	Investigating the effect of WM intervention program on the development of WM.	The program aimed at teaching the strategies for attentiveness and repetition is effective.
23	Willis (2014)	Descriptive	Verbal STM [WMTB-C and AWMA], Visual WM [AWMA]	-	Investigating the visual WM and verbal STM skills of CI users in comparison with hearing children.	(1) Nonword repetition scores of CHL is higher than their word recalls; (2) CHL performed better in visual WM than normally hearing children.
24	Bharadwaj et al. (2015)	Correlational	STM and Verbal Knowledge [KABC-II], Auditory WM [WJ III COG NU], Visual WM [WISC-IV]	Reading [WRMT-III]	Determining the STM and WM of CI users with their relations to reading through auditory and visual tasks.	(1) Visual STM and WM scores are on normal spaces, and STM, WM and all verbal knowledge are below the average limits; (2) Listening and text comprehension both correlate with visual STM, visual and auditory WM.
25	Marshall et al. (2015)	C-C and Correlational	Visual WM [WNSA and The Odd One Out Span Task]	Language [EOWPVT, BSL-NPT, LPP-2]	Comparing deaf children those using sign language as primary mode and those using sign language not in primary mode with hearing children in terms of visual WM and language. Determining the relation between language and WM.	(1) Although they do not use sign language as primary mode, children using sign language displayed lower performance in WM when compared to the other two groups; (2) Both vocabulary and language skills in each of three groups made meaningful contributions to visual WM.

AWMA, Automated Working Memory Assessment ; BASII, British Ability Scales; BKB, Bamford-Kowal-Bench; BRIEF,WM, Working Memory Subtest of the Behavior Rating Inventory of Executive Functioning; BSL-NPT, British Sign Language Narrative Production Test; CAVET, Children's Auditory Visual Enhancement Test; CELF, Clinical Evaluation of Language Fundamentals; CHIVE, Children's Visual Enhancement Test; CHL, Children with Hearing Loss; CI, Cochlear Implant;CLPT, Competing Language Processing Task; CMS, Children's Memory Scale; CMT-CH, Contextual Memory Test for Children; CWM, Combined Working Memory; DMTS, Delayed Matching-to-Sample Task; EOWPVT, Expressive One Word Picture Vocabulary Test; HINT-C, Hearing in Noise Test for Children; HL, Hearing Loss; K-ABC, Kaufman Assessment Battery for Children; KABC-II, Kaufman Assessment Battery for Children II; LNT, Lexical Neighborhood Test; LPP, LanguageProficiencyProfile-2; ND, Nonword discrimination; C-C, Causal-Comparative; NWR, Nonwrod Repetition; PBK, Phonetically Balanced Kindergarten; PI, Phonologically Inaccurate; PIAT, Peabody Individual Achievement Test; PNT, Passive Naming Test; PPVT-III, The Peabody Picture Vocabulary Test–Third Edition; SCR, Sentence Completion and Recall; SDM, Semantic Decision Making; SL & OS, Standardized Reading Comprehension Tests; SR, Serial Recall of Non-words; STM, Short Term Memory; TACL, Test for Auditory Comprehension of Language; TIPS, Text Information Processing System; TORC, Test of Reading Comprehension; TROG, Test for Reception Grammar; VIDSPAC, Video Speech Pattern Contrast Test; VMPT, Visual Matrix Patterns Test; WIPI, Word Intelligibility by Picture Identification; WJ 3 COG NU, Woodcock Johnson 3 Test of Cognitive Abilities; WM, Working Memory; WMTB-C, Working Memory Test Battery for Children; WNSA, Wechsler Nonverbal Scale of Ability; WRAML2, Wide Range Assessment of Memory and Learning Second Edition; WRMT-3, Word Identification subtest ; WS, Word Spotting; WWA, Woodcock Word

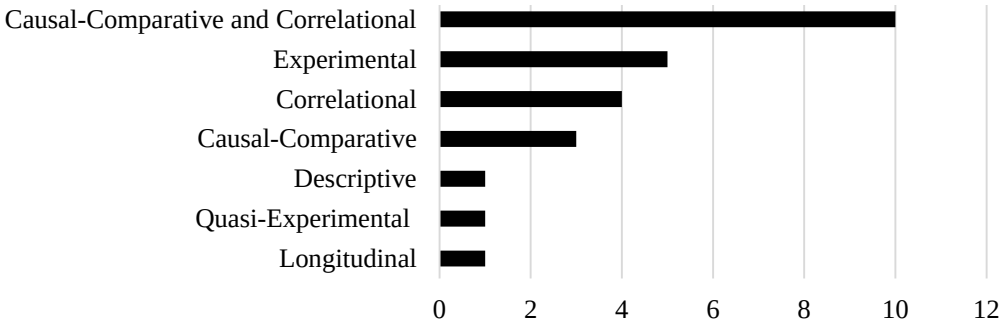

Figure 1. Research models.

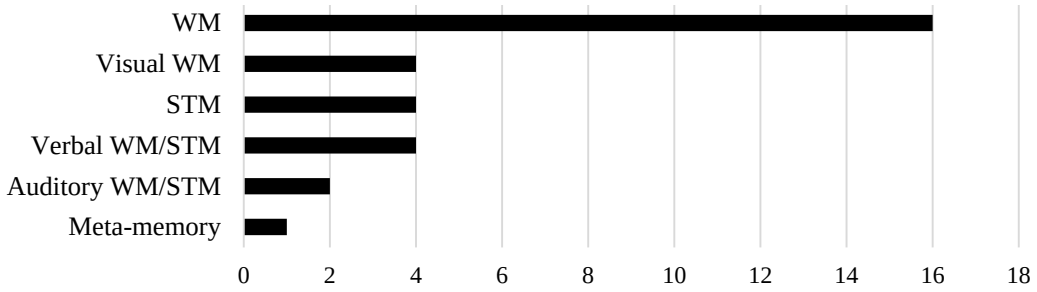

Figure 2. Memory type and measurement tools (WM: Working Memory; STM: Short Term Memory).

Table 4. Measurement tools.

Measurement tools	Frequency (*n*)	Percentage (%)
Standard measurement tools	22	58
Non-standard measurement tools	16	42

standard and non-standard tools.

As shown in Table 5, 53 different standard measurement tools and two different non-standard tools were used to assess the processes related to memory (Table 3).

Aims of the studies

The aims of the studies on memory of children are classified under four groups as follows: To compare children with hearing loss with themselves or with normally hearing children; to analyze the performances of individuals with hearing loss based on different memory types; to relate memory types to some skills, and to determine the effectiveness of intervention programs developed to improve their memory capacity (Table 6).

As clearly displayed in Table 6, 13 studies (52%) aimed to compare groups and to relate skills with memory types. Five of them (20%) were designed to only compare groups, four (16%) were conducted to relate skills with memory types, two (8%) were conducted to determine the effectiveness of intervention programs, and the last one (4%) was designed to examine memory types.

Summary of findings

Findings obtained in accordance with the purpose of this research are organized in line with the frequencies and percentages in Table 6; relevant findings are presented in Table 7.

As shown in Table 7, statistically significant relations were found between memory types and skills in all the studies where groups were compared and skills and memory types were associated. In six (24%) of the studies where normally hearing children and CHL were

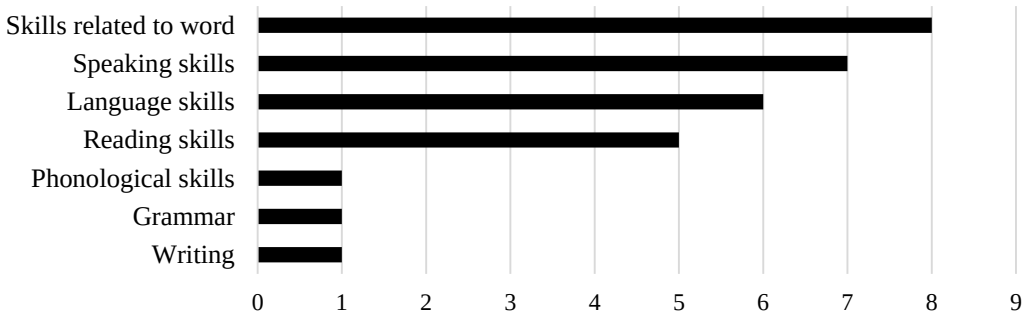

Figure 3. Processes and skills associated with memory.

Table 5. Measurement tools.

Measurement tools	Frequency (*n*)	Percentage
Standard measurement tools	53	96
Non-standard measurement tools	2	4

Table 6. The aims of the studies.

Aims	Frequency	Percentage
Comparing groups / relating skills with memory types	13	52
Comparing groups	5	20
Relating skills with memory types	4	16
Effectiveness of intervention programs	2	8
Examining memory types	1	4

Table 7. Findings of the studies.

Findings	Frequency	Percentage
Between groups comparison/ relationship between skills and memory	13	52
Favored normally hearing children; relations were found	6	24
Favored CHL; relations were found	5	20
Favored total communication users; relations were found	1	4
Favored nnormally hearing children and those whose native language was sign language relations were found	1	4
Between groups comparison	5	20
Favored CHL	1	4
Favored nnormally hearing children	4	16
Relation between skills and memory types	4	16
Related	4	16
Not related	0	0
Effectiveness of intervention programs	2	8
Effective	2	8
Non-eeffective	0	0
Investigation of memory in general	1	4
CHL are competent	0	0
CHL are not competent	1	4

compared, findings were in favor of normally hearing children, while the latter children were favored in five (20%) of them. In one (4%) study where participants using verbal communication and total communication were compared, findings indicated that those using total communication had advantage over the others. However, in another study (4%) where children with normally hearing, those whose native language was sign language, and those using sign language but not as their mother tongue were compared, the results were in favor of both normally hearing participants and those whose native language was sign language.

Findings were in favor of the participants with hearing loss in only one of the studies where the groups were compared. On the other hand, four (16%) studies revealed results favoring normally hearing individuals. Likewise, findings of four (16%) studies conducted to relate skills with memory types yielded significant relations. Furthermore, the results of all studies (8%) designed to examine the effectiveness of intervention programs showed that those programs were effective in improving memory capacities of CHL. There is only one study investigating the types of memory, and its results showed that CHL were incompetent in memory tasks.

DISCUSSION

The aims of this research are to comprehensively examine studies of memory of children in order to determine their population characteristics, topical properties and identify research trends and needs. Within this discussion section, first, findings are grouped and interpreted, and then research needs and suggestions are noted.

Characteristics of participants

The first research question aimed to identify demographic, audiological, and educational features of the participants. With respect to the first group of the findings regarding *demographic characteristics*, the total number of participants in 25 studies is 1943, the number of participants with hearing loss is 1195, and the average number of participants in each study is 48. In a majority of the studies, normally hearing children were included as control groups; and there is a balanced gender distribution among participants with hearing loss. The number of participants in each study is within acceptable limits considering the fact that hearing loss is a rather rare disability compared to others. As a result of this, it is difficult to access if the children in all the groups have to meet specific selection criteria to be included in the research. All of these studies favored normally hearing children as comparison groups. This is quite meaningful since one of the major issues to tackle in special education research is the controversy in comparing disabled children with each other or with other normally developing peers. The dominant side of this dilemma is the idea that it is not possible to draw a plausible conclusion about disabled children without comparing them with normally developing peers in the “norm group”; otherwise, a vital methodological mistake is inevitable (Braden, 2001). Inclusion of normally hearing children as comparison groups in the 25 studies under investigation is consistent with the opinion that it is necessary to employ norm groups in studies whose primary participants are children. Lastly, gender has never been considered as a significant variable in studies conducted on CHL; however, when it comes to cognitive processes—especially visual memory, there is a high probability that performance may vary across genders (Cornoldi and Vecchi, 2003). In fact, the participants were balanced with respect to their genders in most of the 25 studies. And in some of them, they were even matched up based on their genders, and this was the right preference methodologically.

The second finding regarding demographic characteristics indicated that the age range of the children participating in these studies is between 4 years and 18 years and 6 months. Most of the studies do not include any information as to the age at diagnosis. However, some of them report that age at diagnosis ranges from 0 to 13.3 years (mean 1.2), whereas seven of them note that children were diagnosed right after birth. In addition, the age of cochlear implantation ranges from 1 year and 4 months to 10 years, and the duration of cochlear implant use is between 1 and 11 years and 7 months. Integration of these findings leads to three major points: First, one of the selection criteria adopted for this research was that the study participants had to be 18 or below. Naturally, the highest age limit meets this criterion, but none of the studies include children below 4. The reason for this is that many of the studies focused on temporary memory processes (WM and STM), and these types of memories are not available to test children below 4 years (Gathercole et al., 2004). Second, the age range is too wide for all age-related features such as age at diagnosis and age of cochlear implantation, which are included in the demographic variable. The range width indicates that relevant properties have a heterogeneous distribution in this group. This is also consistent with Marschark’s (2006) opinion stating that the group of CHL is highly heterogeneous. Third, almost half of the studies at hand do not reveal any information as to the age at diagnosis, which has a crucial role in cognitive, linguistic, and academic development of CHL. A possible reason for this serious problem may be the difficulty in accessing records since majority of the 25 research studies were conducted retrospectively. On the other hand, it was observed that the age at diagnosis gets lower and lower

in recent research, as shown by those studies providing information about the age at diagnosis. A reasonable explanation for this is the fact that the Universal Newborn Hearing Screening Program, which allows diagnosis of hearing loss right after birth has become more and more common throughout the world (Yoshinaga-İtano, 2003).

Another component of the first research question targets the *audiological characteristics* of the participants with hearing loss. Accordingly, a prominent portion (80%) of the study participants used cochlear implants as hearing technology. Only four of the studies were conducted with children using hearing aids. Similarly, most of the same participants had either severe or profound hearing loss. On the other hand, 40% of the research under investigation provides no information with respect to the degree of hearing loss. A logical conclusion that can be distilled from these findings is that the participants were often cochlear implant users in the studies conducted after the year 2000 on memory of children. This is a very important finding because memory capacity has been regarded as vital along with other factors such as early diagnosis and intervention for language development of children using cochlear implant technology (Pisoni and Geers, 2000). Rather than being a methodological mistake, a probable explanation as to why more than half of the studies do not yield any information regarding the degree of hearing loss may be the fact that cochlear implant technology is only applied to individuals with either severe or profound hearing loss.

The last part of the first research question aims to identify the *educational characteristics* of participants with hearing loss. As for the communication mode, 84% of the participants with hearing loss communicated through the verbal mode, followed by total communication, sign language, and bilingual users employed as comparison groups in four of the studies. This finding is literally consistent with the previous one reporting that a great majority of children used cochlear implants. Thus, it is not new to state that research efforts on memory of children mostly serve the purpose of understanding verbal language development. Analysis of the educational settings provided to children indicates that 70% of them attended inclusive learning classes. This expected finding can be explained by the fact that inclusive educational practices have become more and more common in the world, and that the participants in these studies were eligible for inclusion (Stith and Drasgow, 2005). However, a prominent inadequacy of the studies under investigation is the lack of description of the educational settings provided to the children who did not use the verbal mode or cochlear implant, and who were not in an inclusive learning environment.

Research models

With respect to the second research question, research models employed in those 25 studies were determined. Since only quantitative-empirical studies are included in the present research based on the selection criteria, qualitative research models were excluded. The most frequently used research model in the studies under investigation is the joint use of causal-comparative and correlational models (40%), followed by independent use of experimental, correlational, causal-comparative, descriptive, quasi-experimental, and longitudinal models, respectively. The nature of the CHL group may serve as an explanation as to why causal-comparative and correlational models were adopted more often than the others. Due to the fact that causal-comparative research studies, also known as ex-postfacto examine already existing phenomena, and since hearing loss is not something created by the researcher but precedes the onset of research, it is perfectly understandable to utilize this research model more frequently than other models (Gay et al., 2012). Used to test intervention programs developed to enhance memory capacity, the experimental research model is the second most frequently used in many of the recent studies, which is consistent with others conducted on normally developing children (Spencer-Smith and Klinghberg, 2015). In a sense, memory studies of CHL track the footsteps of those of normally developing children.

Memory type, skills associated with memory and measurement tools

The third and fourth research questions of the current study reflect efforts to identify the memory types, skills associated with memory, and the tools used to measure both memory and associated skills examined in the articles under investigation. Of the 25 studies, 24 focused on working memory and short-term memory. There are two possible reasons why these two types of memories were studied so vastly. First of all, although it is still debatable that the two memory types reflecting temporary memory are totally different from each other, it is widely accepted that temporary memory is the key to explaining all kinds of academic learning and learning disabilities (Alloway and Gathercole, 2006). Considering that almost all studies were conducted with children with cochlear implants, the need to reveal the individual differences leading to learning or not learning academic skills and achievement of or failure to achieve language development may have driven researchers to focus on temporary memory processes. Moreover, the detailed definition of measurement paradigms and tools utilized to determine these memory types may be given as the second reason. Assessment of these memory types is relatively more concrete than that of other types of memory in both auditory and visual modalities (Gathercole et al., 2004).

Within 32% of the articles under investigation, “memory” was not associated with any skill. Across the rest of the studies, memory was mostly associated with vocabulary, speaking, language, reading, phonological, grammar, and writing skills, respectively. A closer look at the data set showed that memory was highly associated with the groups of verbal language and literacy skills.

Pisoni (2000) emphasized that the role of audiological and educational variables such as hearing technology, early diagnosis, and early education is mostly underpinned during the explanation of language and academic development in CHL while the role of cognitive variables is generally ignored. Examination of studies conducted after the year 2000 shows that Pisoni’s concern regarding the effect of memory in explaining the individual differences across language and academic skills is also shared by other researchers.

Another noteworthy point regards the measurement tools. Approximately half of the tools employed to measure memory were standard ones and the other half were non-standard ones (tasks). Yet, almost all the tools used to assess language and literacy skills associated with memory were standard ones. Again, the use of more than one tool to measure either memory or associated skills is common across the studies examined in this research. A multi-measure paradigm (that is, use of more than one tool to measure the same thing in order to improve reliability) is frequently adopted in the 25 studies (Stevens, 2009). Thus, it is plausible to state that the studies included in the current research paid due attention to measurement reliability. Despite this positive remark, it is obvious by the measurement tools used in the 25 studies that these two memory types (working memory and short-term memory) were not differentiated in practice, but in theory, which is proven by the existence of studies employing the same measurement tool for both working memory and short- term memory.

The main aims and findings of the studies

The fifth and sixth research questions relate to the main aims and findings of the studies. Of all 25 studies, 52% aimed simultaneously at comparing groups and building relations between memory types and skills. However, the rest of the studies were designed to compare groups, associate skills with memory types, determine the efficacy of intervention programs, and understand the nature of memory of CHL in isolation and respectively. As reported earlier, the most frequently employed research model among the 25 articles under investigation is a joint use of causal-comparative and correlational models, which indicates that aims and models match perfectly. Therefore, one can conclude that the studies examined in the present research are methodologically solid with respect to their research models.

Pertinent to the aims, there are two emerging groups of findings. According to the first group, there are meaningful positive relations with varying numerical values between memory capacity and skills (e.g., vocabulary, speaking, language, reading, phonology, grammar, and writing). This group of findings points out that cognitive processes, at least on the memory level, are effective over the development of aforementioned skills in CHL as well as their demographic, audiological, and educational features (Pisoni, 2000). An interesting finding has been identified regarding the aim of cross-group comparison. In 10 out of the 15 studies, it is concluded that memory capacity is in favor of normally hearing children whereas CHL were determined to have better memory capacities in five studies. In all the studies where temporary memory capacity is identified to be stronger for CHL, measurement tools are presented in visual modality. Obtaining this finding even in 33% of 15 studies means that Parasnis et al. (1996) warning as to investigating sensory compensation hypothesis in detail has been confirmed. According to the sensory compensation hypothesis, the span of visual memory in individuals with hearing loss is wider than that of normally developing individuals and it functions to compensate for the deficiency created by the relevant sensory loss. Even though the studies within the scope of the current research did not produce enough findings to make any generalizations concerning the sensory compensation hypothesis, they yielded strong enough clues to further question the hypothesis.

CONCLUSION AND SUGGESTIONS

At the end of this research, two kinds of trends have been determined: Methodological and topical. Considering that only one study bearing the selection criteria has been conducted in our country so far; each emerging trend naturally points to a research need, in other words, a suggestion.

Methodological trends and suggestions

Four basic methodological trends have been determined in this research examining 25 quantitative-empirical studies. As for the first trend, normally hearing children are included as norm groups in the studies investigating memory and related processes in CHL. Thus, the use of normally hearing children as norm groups will provide a more holistic assessment of the target group even if CHL are evaluated without comparison to the norm groups. Forming norm groups for research is not limited to memory studies; they are also used in language, reading, writing, and other academic and cognitive skill studies. Moreover, referring to normally hearing children during

research efforts will also reveal over time significant information as to the validity of the sensory compensation hypothesis.

The second methodological trend is that the individual differences among participants are quite numerous. In addition to general features such as gender and age, other variables specific to participants with hearing loss such as age at diagnosis, age of implantation, hearing level, level of hearing loss, hearing technology, primary communication mode, and educational features make this group of participants extremely heterogeneous.

Therefore, researchers planning to conduct memory studies of CHL should define the relevant variables in detail and should control them as tightly as possible. Otherwise, the findings will be difficult to generalize.

As for the third trend, most of the studies utilize a joint design of causal-comparative and correlational research models. However, an increase in the use of experimental models has been noted. Thus, it is reasonable to expect a rise in experimental studies on an international scale and to hope for a beginning in terms of causal-comparative and correlational research studies in our country before transcending to experimental models. With respect to practice, it is of crucial importance to develop experimental research on intervention programs.

According to the fourth methodological trend, measurement of both memory and related skills is based on a multi-measurement paradigm (that is, measuring the same feature by more than one tool) (Stevens, 2009) which is vital for measurement reliability. The multi-measurement paradigm deserves special interest and attention in terms of research on memory and related skills in individuals with special need, including CHL.

Topical trends and suggestions

Four basic topical trends have been identified as a result of analyzing the studies within the scope of the current research. As for the first common trend, memory research has predominantly been conducted on children with cochlear implants. Although the use of cochlear implants may be interpreted as a methodological trend because of being one of the participants' characteristics, the influence it has over the lives of CHL turns it into a single topic on its own. Similarly, the participants of the 25 studies are vastly children using verbal communication as their primary mode. As a result, one can conclude that a serious amount of research should be conducted on memory and related skills in CHL administered cochlear implant using verbal language mode. This trend indicates an important study area for researchers in our country. On the other hand, the rates of children who use hearing aids and communicate through verbal language and who make use of sign language with or without hearing technology are also considerably high, which unravels another research need.

The second topical trend is the relation between memory and language and literacy skills in children. Statistically significant and positive relations are determined between memory and language and literacy skills in all the studies examined in this research. For future research, one can suggest that the strength of memory capacity in explaining language and literacy skills be studied. If future research efforts take demographic, audiological, and educational features into account, it may be possible to determine which of these variables is more effective on the development of the skills mentioned earlier. After clearly stating the effect of memory, the questioned if intervention programs designed to enhance memory capacity have any slight influence over language and literacy skills may arise.

Inclusive educational practice is the third topical trend. In most of the studies, the participants attend inclusive classes. Thus, inclusive practice, as an educational setting, has become a topic of research not only in terms of language, literacy, and other academic skills, but also in terms of cognitive processes such as memory. The relation inclusive education has with the cognitive processes of CHL may also be a topic of study for researchers in our country.

The last topical trend is the focus on temporary memory processes such as short-term memory and working memory in almost all the studies conducted on memory in CHL. Considering the relation it has with language, academic learning, and learning disabilities, examining temporary memory processes is perfectly understandable. All of these indicate major research topics for our country. However, the results of the current study yield that other memory types such as implicit memory, autobiographic memory, semantic memory, episodic memory, and procedural memory in CHL have been neglected in both national and international literature. Therefore, these memory types may very well serve as study topics for future research endeavors.

General suggestions

All the methodological and topical trends mentioned above prescribe research needs for researchers in Turkey. No direct suggestion has been distilled for practice based on the results of this study. Nevertheless, two indirect suggestions may be deduced. First, using a multi-measurement paradigm during the assessment of CHL may increase the reliability in practice as well as in theory no matter what the aim is. Second, taking temporary memory processes into account while investigating the causes of difficulties that children have in acquiring language, literacy, and other academic skills might improve the validity of assessment.

Finally, this research has analyzed quantitative-

empirical studies conducted during the 16-year span between 2000 and 2015. Focusing on the studies conducted earlier than 2000 may help to observe the changes especially within topical trends over time.

Conflict of Interests

The authors have not declared any conflict of interests.

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