Factors relevant to investigating working memory and sentence comprehension in healthy aging

Introduction

The relationship between working memory (WM) and sentence comprehension (SC) has drawn many researchers' attention. There are studies which have explored the connection between reduced WM and SC deficits in aphasia (Caspari, Parkinson, LaPointe, & Katz, 1998; Friedman & Gvion, 2003; Martin, Kohen, & Kalinyak-Fliszar, 2008; Wright & Shisler, 2005; Wright, Downey, Gravier, Love, & Shapiro, 2007), as well as studies examining the relationship in elderly adults (Kemper, Crow, & Kemtes, 2004; Kemper & Herman, 2006; Kwong See, & Ryan, 1995). Studies on aging effects for these two factors are important as baseline data to compare with studies on aphasic adults, who are typically older. Most studies on WM and SC have focused on whether WM or SC is reduced in elderly adults or aphasics, and whether any differences in SC may be explained by age-related differences in WM (Baum, 1991; Christianson, Willams, Zacks, & Ferreira, 2006; Davis & Ball, 1989; Feier & Gerstman, 1980; Kemtes & Kemper, 1997, Kemper & Liu, 2007; Kemper & McDowd, 2006; Stine-Morrow, Ryan, & Leonard, 2000; Fallon, Peelle, & Wingfield, 2006). However, there is conflicting evidence regarding whether elderly adults exhibit different SC behaviors from younger adults based on differences in WM. There is no study to date which has reviewed what factors could explain the conflicting effects found in studies of WM and SC in healthy aging. Thus, other factors which may be relevant to detecting aging effects across the studies regarding WM and SC need to be investigated.

Aims

The aim of the current study is to determine which factors are the most important for detecting age-related differences in studies on WM and SC.

Method & Procedures

A literature review of all studies in PubMed, Ovid, and PsycINFO databases was conducted targeting all studies examining Aging, WM and SC. We found a total 8,858 studies with the three key words, and chose 33 key articles directly related to the current topic among those for analysis in this study. The selected articles were chosen because they met all three of the following criteria: 1) the articles reported measures of WM related to age difference, 2) the articles measured differences in SC based on age difference, and 3) the articles addressed the relationship between WM and SC based on age difference.

An analysis was performed to isolate key factors which could explain the different results across these studies. Five potential factors were identified: 1) Sentence type tested; 2) Methods of sentence presentation; 3) Number of participants; 4) Participant age range; and 5) On-line versus off-line measurements.

Results

1) Sentence type tested

Across studies, three different types of sentences were tested: right-branching vs. left-branching sentences, subject-extracted versus object-extracted sentences, and ambiguous versus unambiguous sentences. Studies comparing left-branching versus right-branching sentences found mixed results. Elderly adults have been found to exhibit more difficulty in imitating or

comprehending left-branching sentences (Kemper, 1986, 1987; Kynette & Kemper, 1986), but Davis & Ball (1989) found that right-branching sentences were more difficult than left-branching sentences. In contrast, studies comparing subject-extracted and object-extracted sentences have found more consistent age-related differences. Stine-Morrow, Ryan, & Leonard (2000) and Zurif, Swinney, Prather, Wingfield, & Brownell (1995) both found that elderly adults exhibited slower/poorer performance for object-relative sentences, but found no age-related difference for subject-relative sentences. Studies comparing ambiguous and unambiguous sentences have found that age-related differences in SC interact with WM. Elderly adults exhibited greater processing difficulty in ambiguous than unambiguous sentences, as measured by reading times at the critical region (Kemper, Crow & Kemtes, 2004) or comprehension question accuracy (Christianson, Williams, Zacks & Ferreira, 2006). Age-related performance differences also interacted with WM: High span WM readers showed less difficulty than low span WM readers in processing ambiguous sentences, particularly among older adults (Christianson, Williams, Zacks & Ferreira, 2006).

2) Method of sentence presentation

The methods used for sentence presentation varied across studies: self-paced listening/reading, eye-movement monitoring, auditory moving window paradigm, a word-monitoring paradigm, cross-modal lexical priming, listening to recorded sentences, and paper-and pencil format. However, specific points of age-related difference based on different methods were not observed.

3) Number of participants

The number of subjects was not related to the different results, or if there were differences between old and young adults according to WM, SC, and the relationship between WM and SC. Studies which found age-related differences and studies which did not had similar numbers of participants.

4) Age range

Age range was related to the likelihood of finding age-related differences. Davis and Ball (1989) and Feier and Gerstman (1980) found evidence of age-related decline in comprehension accuracy only after age 60.

5) On-line and off-line measurements

Almost all off-line studies (nearly three-fourths) which were reviewed in this study found aging effects on SC, while results from on-line studies were more variable: some found age-related differences (Kemper, et al., 2004), while others did not (Dede, Caplan, Kemtes & Waters, 2004). However, more recent studies have primarily employed on-line instead of off-line methods.

Conclusion & Discussion

Among the five factors, age-related differences were observed for the following three factors: sentence type tested, participant age range, and on-line vs. off-line measurements. Age-related differences were more likely to be found for object-extracted sentences and for ambiguous sentences, and more likely to be found for adults over the age of 60. Furthermore, studies employing off-line measures were more likely to find age-related differences. These

results should be considered when designing studies of sentence comprehension aphasic patients, as the effects of these factors could be confounded with healthy aging effects if the aphasics are elderly adults, as most adults with aphasia are.

Table 1

	The reviewed studies for this study	category
1	Salthouse & Babcock (1991)	WM
2	Bopp & Verhaeghen (2005)	WM
3	Gick et al. (1888)	WM
4	Hartley (1986)	WM
5	Hartley (1988)	WM
6	Light & Anderson (1985)	WM
7	Marmurek (1990)	WM
8	Pratt & Robins (1991)	WM
9	Stine & Wingfield (1987)	WM
10	Stine & Wingfield (1990)	WM
11	Tun et al. (1991)	WM
12	Wingfield, Stine, Lahar, Aberdeen (1988)	WM
13	Pelosi & Blumhardt (1999)	WM
14	Davis & Ball (1989)	SC
15	Obler et al (1991)	SC
16	Christianson et al. (2006)	SC
17	Stine-Morrow, Ryan, & Leonard (2000)	SC
18	Kemper (1986)	SC
19	Kynette & Kemper (1986)	SC
20	Fallon, Peelle, & Wingfield (2006)	SC
21	Feier & Gerstman (1980)	SC
22	Kemtes & Kemper (1997)	SC
23	Kemper & Liu (2007)	SC
24	Baum (1991)	SC
25	Kemper & McDowd (2006)	SC
26	Kemper & Herman (2006)	WM-SC
27	Kemper, Crow, & Kemtes (2004)	WM-SC
28	Zurif, Swinney, Prather, Wingfield, & Brownell (1995)	WM-SC
29	Kwong See et al. (1995)	WM-SC
30	Kemper & Kemetes (1999)	WM-SC
31	Waters & Caplan (2001)	WM-SC
32	Dede, Caplan, Kemtes, & Waters (2004)	WM-SC
33	Linden et al. (1999)	WM-SC

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