



Verbal learning and memory in agenesis of the corpus callosum



Roger L. Erickson^a, Lynn K. Paul^b, Warren S. Brown^{a,*}

^a The Travis Research Institute, Fuller Graduate School of Psychology, 180 N. Oakland Avenue, Pasadena, CA 91101, USA

^b Division of Humanities and Social Sciences, California Institute of Technology, MC 228-77, Pasadena, CA 91125, USA

ARTICLE INFO

Article history:

Received 27 March 2014

Received in revised form

3 June 2014

Accepted 4 June 2014

Available online 13 June 2014

Keywords:

Corpus callosum

Verbal learning

Verbal memory

Encoding

ABSTRACT

The role of interhemispheric interactions in the encoding, retention, and retrieval of verbal memory can be clarified by assessing individuals with complete or partial agenesis of the corpus callosum (AgCC), but who have normal intelligence. This study assessed verbal learning and memory in AgCC using the California Verbal Learning Test—Second Edition (CVLT-II). Twenty-six individuals with AgCC were compared to 24 matched controls on CVLT-II measures, as well as Donders' four CVLT-II factors (i.e., Attention Span, Learning Efficiency, Delayed Memory, and Inaccurate Memory). Individuals with AgCC performed significantly below healthy controls on the Delayed Memory factor, confirmed by significant deficits in short and long delayed free recall and cued recall. They also performed less well in original learning. Deficient performance by individuals with AgCC during learning trials, as well as deficits in all forms of delayed memory, suggest that the corpus callosum facilitates interhemispheric elaboration and encoding of verbal information.

© 2014 Published by Elsevier Ltd.

1. Introduction

Learning and memory are not unitary functions, but are multi-component (i.e., encoding, consolidation, retrieval, and recognition), and multi-modal (e.g., auditory, visual, olfactory, and motor) processes that involve a variety of brain regions (e.g., the medial temporal lobe, frontal lobes, cerebellum, amygdala, neocortex, and striatum). Conceptualizations of learning and memory have evolved over time, emerging from various philosophical and psychological theories (Maine de Biran, 1804/1929; James, 1890), experimental research with animals (Gaffan, 1974; O'Keefe & Nadal, 1978), and studies of humans with organic or acquired biological conditions (Milner, 1962; Benzing & Squire, 1989). Much of our current knowledge about memory has come from assessing learning and memory in different clinical populations (e.g., patients with amnesia, alzheimers). With this in mind, the primary goal of the current study is to further clarify the role of the corpus callosum in verbal learning and memory. This will be accomplished by comparing performance of a large sample ($n=26$) of individuals with agenesis of the corpus callosum (AgCC) against matched controls using the California Verbal Learning Test—Second Edition (CVLT-II; Delis, Kaplan, Kramer, & Ober, 2000).

1.1. Agenesis of the corpus callosum

AgCC is a congenital brain malformation involving the complete or partial absence of the largest interhemispheric pathway. Current estimates suggest that AgCC occurs at a prevalence rate of approximately 1:4000 within the general population (Glass, Shaw, Ma, & Sherr, 2008) and at a rate of 3–5:100 in the developmentally disabled population (Jeret, Serur, Wisniewski, & Fisch, 1985). AgCC results from a variety of toxic, genetic, or vascular causes, but only 30–45% of individuals have identifiable causes for their AgCC diagnosis (Paul et al., 2007). Because callosal connections are absent from birth, the brain is challenged to maximize compensatory networks that would otherwise be mediated via the callosum. It is reasonable to presume that these compensatory systems are fully engaged by adulthood, at which point the remaining cognitive impairments shared among the AgCC population are most likely to reflect functions that are uniquely dependent on the callosum. Generally, congenital callosal malformations are demarcated into three specific categories: complete agenesis (complete AgCC), partial agenesis (partial AgCC), and callosal hypoplasia (Rauch & Jinkins, 1994). This approach to isolating the callosal contributions to higher cognitive functions is most effective in the sub-population of individuals with isolated AgCC. These individuals have either complete or partial AgCC, exhibit generally intact intellectual functioning with Full Scale Intelligence Quotient (FSIQ) greater than 80, and have few (if any) other cerebral malformations.

* Corresponding author. Tel.: +1 626 584 5525; fax: +1 626 584 9630.

E-mail address: wsbrown@fuller.edu (W.S. Brown).

Isolated AgCC results in a pattern of neuropsychological and social deficits. Starting with basic sensory-motor processes, individuals with complete and partial AgCC have mild to moderate difficulties on tasks necessitating bimanual coordination of motor movements (Jeeves, Silver, & Jacobson, 1988; Jeeves, Silver, & Milner, 1988; Mueller, Marion, Paul, & Brown, 2009) and on tachistoscopic tasks that assess interhemispheric transfer of complex sensory information (Brown, Jeeves, Dietrich, & Burnison, 1999; Imamura, Yamadori, Shiga, Sahara, & Abiko, 1994; Jeeves, 1979; Jeeves & Silver, 1988; Karnath, Schumacher, & Wallesch, 1991; Sauerwein & Lassonde, 1983). For example, Brown et al. (1999) showed that individuals with AgCC performed similar to controls when presented with bilateral single letter matching tasks, but showed a bilateral presentation disadvantage when the task required matching complex patterns that were novel and not easily verbalized.

On cognitive tasks, their performance is characterized by slow reaction times and processing speed, particularly when processing complex information (Brown et al., 1999; Brown, Thrasher, & Paul, 2001; Hines, Paul, & Brown, 2002; Marco et al., 2012). On Wechsler IQ measures, surveys of published cases of individuals with AgCC and normal IQ have not revealed any consistent pattern of Verbal-Performance discrepancies (Chiarello, 1980; Sauerwein & Lassonde, 1994). Socially, they exhibit impaired comprehension of higher-order aspects of communication, affecting language pragmatics and humor (Brown, Paul, Symington, & Dietrich, 2005; Brown, Symington, VanLancker-Sidtis, Dietrich, & Paul, 2005; Paul, Van Lancker-Sidtis, Schieffer, Dietrich, & Brown, 2003), theory of mind (Symington, Paul, Symington, Ono, & Brown, 2010), and interpersonal relations (Brown & Paul, 2000; Turk, Brown, Symington, & Paul, 2010). It has been suggested that AgCC involves a core cognitive deficit in complex novel problem-solving (Brown & Paul, 2000; Gott & Saul, 1978; Sauerwein & Lassonde, 1994; Smith & Rourke, 1995; Solursh, Margulies, Ashem, & Stasiak, 1965). Specifically, Brown and Paul (2000) found that two individuals with AgCC exhibited performance at the level of their FSIQ on a task involving over-learned information (crystallized intelligence), but under-performed on tests that assessed more creative and complex cognitive problem solving skills (e.g., the Tactile Performance Test, Raven's Color Progressive Matrices, Categories Test, and the Letter and Number Series Tests). However, it has been unclear whether deficits in verbal learning and memory are a part of the cognitive profile of AgCC.

1.2. Corpus callosum and memory

Early studies of memory in commissurotomy patients were inconclusive. Some studies reported intact memory functioning (LeDoux, Risse, Springer, Wilson, & Gazzaniga, 1977) and indicated that an isolated hemisphere could functionally encode as well as retrieve verbal information (Sperry, 1968). In contrast, other studies (Zaidel & Sperry, 1974; Zaidel, 1990) found that when compared against controls and individuals with epilepsy, post-operative commissurotomy patients performed more poorly on standardized tests of both verbal and visual-spatial memory. Impaired performance of commissurotomy patients on the verbal paired associates subtest of the Wechsler Memory Scale (WMS; Wechsler, 1945) suggested that the cerebral commissures play an important role in the acquisition, consolidation, and retrieval of verbal information. One hypothesis suggested that elimination of interhemispheric transfer impaired performance because visual memory traces in the right hemisphere were inaccessible to the language dominant left hemisphere for verbal recall. Moreover, reduced interaction of visual and verbal systems may have limited the richness of initial encoding for both visual and verbal tasks. A second hypothesis suggests that these findings could be

interpreted in terms of difference in the respective ability of the two hemispheres to process different aspects of linguistic information, with the right hemisphere having increased semantic processing ability relative to the left. These studies suggest that the corpus callosum may play a role in the facilitation of different memory functions; however since commissurotomy involves transection of all cerebral commissures, including the hippocampal commissure, it does not specifically isolate the impact of callosal disconnection (Clark & Geffen, 1989; Phelps, Hirst, & Gazzaniga, 1991).

Early small-sample studies of learning and memory in individuals with AgCC and normal range IQ have been inconclusive. Some studies revealed relatively intact performance (Gott & Saul, 1978; Kessler, Huber, Pawlik, & Heiss, 1991; Pirozzolo, Pirozzolo, & Ziman, 1979). Specifically, Kessler et al. (1991) reported unimpaired verbal memory and recall performance in a 45-year-old male on the Buschke's Selective Reminding Paradigm (SRT; Buschke, 1973). Similarly, Pirozzolo et al. (1979) reported that a 60-year-old male with AgCC achieved a Memory Quotient score in the high average range (88th percentile) on the Wechsler Memory Scale (WMS; Wechsler, 1945). In contrast, Gott and Saul (1978) reported that an individual with AgCC received a low average Memory Quotient score. The Wechsler Memory Quotient score, a composite score of different verbal and visual memory tasks, was only reported in these papers and therefore no information was available regarding strengths or weakness on specific memory types or processes (i.e., encoding, consolidation, retrieval, and recognition).

Several studies found that individuals with isolated AgCC have recall impairments on tests of verbal learning and recall of word lists (Fischer, Ryan, & Dobyns, 1992; Geffen, Forrester, Jones, & Simpson, 1994; Panos, Porter, Panos, Gaines, & Erdberg, 2001). First, Fischer et al. (1992) administered a selective reminding paradigm test to two children with AgCC (both age 8) with normal-range IQ. One individual performed in the 5th percentile and the other in the 16th on long-term retrieval of verbal information. In another study, the Rey Auditory Verbal Learning Test (RAVLT; Rey, 1958) was administered to four individuals with AgCC and FSIQ > 80, (Geffen et al., 1994). Three participants (ages 10, 14, and 37) had complete AgCC and one participant (age 22) had partial AgCC. Relative to published norms, the participants with AgCC did not exhibit deficits (i.e., performance at or below one standard deviation from test norms) on qualitative aspects of learning (i.e., learning slope, proactive and retroactive interference, or metamemory); however, the two children with complete AgCC had deficient acquisition scores (i.e., poor initial recall and total recall over Trials 1–5). On delayed recall, all three individuals with complete AgCC exhibited deficits in free recall, despite intact recognition. This pattern of performance suggests that they encoded and retained the verbal information, but had difficulty retrieving it from memory without the help of external cues. The author hypothesized that since recall deficits were not evident in the individual with partial AgCC, the remaining portion of the corpus callosum must play a role in the proper consolidation and retrieval of verbal information (Geffen et al., 1994). A later case study of an 11-year-old with partial AgCC and intact FSIQ (Panos et al., 2001) reported impaired recall on the California Verbal Learning Test—Children's Version (CVLT-C; Delis, Kaplan, Kramer, & Ober, 1994). Unlike the complete AgCC cases reported by Geffen et al., this child with partial AgCC performed more poorly on the cued recall (two standard deviations below the mean) than on free recall (one standard deviation below the mean). The authors suggest that his poor cued memory illuminates a broader impairment in language processing, characterized by “limited capacity to utilize semantic information to organize his learning or recall.” In sum, while there is evidence that memory impairment may be a

Download English Version:

<https://daneshyari.com/en/article/7321308>

Download Persian Version:

<https://daneshyari.com/article/7321308>

[Daneshyari.com](https://daneshyari.com)