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Review

Handedness prevalence in the deaf: Meta-analyses

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ABSTRACT

An under-investigated aspect of handedness, a biological proxy for cerebral laterality for language, is its prevalence amongst deaf individuals. We present four sets of meta-analyses on studies measuring handedness prevalence in deaf individuals, comprising 31 data sets and totaling 5,392 participants (4,606 deaf, 786 hearing). Deaf individuals were found to be 2.61 times more likely to be non-right-handed and 2.25 times more likely to be left-handed compared to their hearing counterparts. When handedness was measured by means of manipulative actions, the weighted estimates of handedness prevalence for deaf populations were 17.70% and 14.70% for non-right- and left-handedness respectively; when handedness was measured by means of sign actions, the prevalence was 10.60% and 9.70%, respectively. Yet, when comparing studies that measured handedness in the same deaf individuals using both manipulative and sign actions, no difference was found in their handedness prevalence. This pattern is taken to suggest that the higher prevalence of atypical handedness in the deaf population may be linked to delayed language acquisition.

Contents

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1. Introduction

The degree to which innate constraints and environmental effects control individual differences in neurological organization is a central question in cognitive neuroscience. The cerebral organization of language functions in deaf individuals is an excellent area for such an investigation for two main reasons: (i) in cases of auditory deprivation, vision overtakes audition as the primary modality supporting communication (i.e., the aural-oral modality of spoken language vs. the visuospatial modality of sign languages), and (ii) delays in the age of acquisition of language in deaf children are common, especially among children of hearing parents. Auditory deprivation, sign language use, and delayed language acquisition may lead to atypical cerebral and behavioural lateralization in deaf individuals.

Language processing is underpinned by a distributed cerebral network with differences in regional involvement related to specific language subfunctions, but with essential regions within this network typically lateralized to the left hemisphere (Vigneau et al., 2006). While most studies on language lateralization investigate spoken languages, there is now ample evidence that the same cortical substrates are involved in the processing of sign languages. Studies on the effects of brain damage in deaf sign language users, for example, have reported that sign language was affected specifically by damage to the left hemisphere (Buchsbaum et al., 2005; Corina, 1998; Hickok et al., 2002; Marshall et al., 2004; Poizner et al., 1987). Neuroimaging studies also provide ample evidence for the role of the left hemisphere in sign language (e.g., Emmorey et al., 2015; for a review see MacSweeney et al., 2008). A crucial difference between signed and spoken languages seems to lie in the fact that sign language processing requires the contribution of the right hemisphere to a greater extent (Campbell et al., 2007). Event-related potential studies have indeed shown that syntactic processing for sign language was bilateral rather than left-sided, as is characteristic of spoken languages (Capek et al., 2001). Functional magnetic imaging studies have yielded findings that point to the same direction (e.g., MacSweeney et al., 2008; Söderfeldt et al., 1994; Söderfeldt et al., 1997) and so have positron emission tomography studies (e.g., Petitto et al., 2000; Emmorey et al., 2014).

The neurobiological substrate for language is linked to handedness and manual praxic lateralization, albeit weakly (for reviews see Corballis et al., 2012; Papadatou-Pastou, 2011). A wealth of evidence points in this direction, including studies using the Wada technique (Alekoumbides, 1978; Rasmussen and Milner, 1975, Rasmussen and Milner, 1977), rTMS (Khedr et al., 2002), and fMRI (Pujol et al., 1999; Springer et al., 1999). Knecht et al. (2000) measured lateralization directly by functional transcranial Doppler ultrasonography in 326 healthy hearing individuals and showed that the incidence of right-hemispheric dominance increases linearly with the degree of left-handedness, from 4% in strong right-handers, to 15% in ambidextrous individuals, to 27% in strong left-handers. As a result, handedness is often employed as a biological proxy for cerebral lateralization for language, especially in cases where cerebral laterality cannot be readily observed. The prevalence of left-handedness in the general population is usually taken to be around 10% (e.g., Perelle and Ehrman, 1994; Peters et al., 2006). However, there is variation related to, for example, participants' age and sex as well as how handedness is measured (Gilbert and Wysocki, 1992; Papadatou-Pastou et al., 2008; Papadatou-Pastou et al., 2013).

1.1. Distribution of left-handedness among the deaf

A number of studies have investigated handedness patterns in deaf populations, with the majority pointing in the direction of elevated rates of atypical handedness (i.e., left-, mixed-, and non-right-handedness) within these populations compared to general population estimates. For example, Bonvillian et al. (1982) reported questionnaire data from 226 high school and college students, and Dane and Gümüstekin (2002) collected data from 91 schoolchildren (7–15 yr of age). Both of these studies found that the prevalence of right-handedness was around 90% in the hearing control group, but lower among deaf participants (85.4% and 79.1%, respectively). Two other studies (Mandal et al., 1999; Weston and Weinman, 1983)