



Research article

Callosotomy affects performance IQ: A meta-analysis of individual participant data

René Westerhausen^{a,b,*}, Celine M.R. Karud^a^a Center for Lifespan Changes in Brain and Cognition (LCBC), Department of Psychology, University of Oslo, Oslo, Norway^b Department for Biological and Medical Psychology, University of Bergen, Bergen, Norway

ARTICLE INFO

Keywords:

Corpus callosum
Intelligence
Callosotomy
Split-brain
Meta-analysis

ABSTRACT

Morphometric neuroimaging studies on healthy adult individuals regularly report a positive association between intelligence test performance (IQ) and structural properties of the corpus callosum (CC). At the same time, studies examining the effect of callosotomy on epilepsy patients report only negligible changes in IQ as result of the surgery, partially contradicting the findings of the morphometry studies. Objective of the present meta-analysis of individual participant data (IPD) of 87 cases from 16 reports was to re-investigate the effect of callosotomy on full scale IQ as well as on the verbal and performance subscale under special consideration of two possible moderating factors: pre-surgical IQ levels and the extent of the surgery (complete vs. anterior transection). The main finding was that callosotomy selectively affects performance IQ, whereby the effect is modulated by the pre-surgical level of performance. Patients with an above-median pre-surgery performance IQ level show a significant average decrease of -5.44 ($CI_{95\%}$: -8.33 to -2.56) IQ points following the surgery, while the below-median group does not reveal a significant change in IQ (mean change: 1.01 IQ points; $CI_{95\%}$: -1.83 to 3.86). Thus, the present analyses support the notion that callosotomy has a negative effect on the patients' performance IQ, but only in those patients, who at least have an average performance levels before the surgery. This observation also lends support to the findings of previous morphometry studies, indicating that the frequently observed CC-IQ correlation might indeed reflect a functional contribution of callosal interhemispheric connectivity to intelligence-test performance.

1. Introduction

The intellectual and cognitive abilities usually summarized as intelligence are supported by a large-scale brain network encompassing association cortices in frontal, parietal, and temporal lobes [6,13]. As this network is distributed across both cerebral hemispheres, it has been suggested that hemispheric interaction via the commissures has an important role in higher intellectual abilities [1,5,16,30]. This notion, is supported by a series of neuroimaging studies demonstrating an association between intelligence scores (IQ) and corpus callosum (CC) measures [4,7,14,22,25,26,31]. In healthy adult individuals, for example, a thicker mid-sagittal CC [14] or higher callosal fractional anisotropy (indicative for stronger axon myelination) [7] has been found to be positively predictive for higher intellectual performance. Evidence for a common genetic origin for CC size or fractional anisotropy with IQ scores from heritability studies [11] and target-gene approaches [21] also support this view. The correlational nature of the above studies prevents, however, any strong conclusion regarding the “causal” relevance, or necessity, of hemispheric connectivity for high intellectual

performance [9]. In fact, it has been suggested that this CC-IQ correlation might be in itself “non-functional” and rather reflect differences in the neuron population in the interconnected cortices that only secondarily affect callosal connectivity [25]. However, one way to substantiate the notion of a causal link is to study the effect of severing the corpus callosum (callosotomy) on intelligence in a pre- vs. post-operative comparison. Such comparison usually reveals that the effect of callosotomy—traditionally performed as treatment to reduce the effect of epileptic seizure—on IQ is negligible [15,19,27]. For example, Mamelak et al. [15] examined 15 epilepsy patients aged between 9 and 31 years and found no substantial change in verbal (mean change in v-IQ: 0.38 , $SD = 3.52$) or performance IQ (change in p-IQ: 1.23 , $SD = 3.56$).

Nevertheless, reviewing the available literature it is also obvious that two important factors which potentially might influence the effect of the callosal surgery have not been systematically addressed. These are the level of pre-surgical intelligence and the extent of the surgery (i.e., whether a complete or partial transection was performed). Thus, the objective of the present meta-analysis of individual participant data (IPD) was to assess the effect of callosal surgery on intelligence test

* Corresponding author at: Center for Lifespan Changes in Brain and Cognition (LCBC), Department of Psychology, University of Oslo, POB 1094, Blindern, 0317 Oslo, Norway.
E-mail address: rene.westerhausen@psykologi.uio.no (R. Westerhausen).

performance under consideration of these potential moderating factors in order to supplement the correlational evidence from previous neuroimaging studies.

2. Material and methods

2.1. Study and case identification

As IQ scores are usually reported to give a closer description of the patients without being of interest for the primary study (which addressed a wide variety of different research questions), the aim of the literature search was to identify all articles in which one or more callosotomy patients are described and screen these for relevant data. Thus, in May 2017 the literature search in ISI Web of Knowledge ([apps.isiknowledge.com](https://www.isiknowledge.com)) and PubMed (www.ncbi.nlm.nih.gov/pubmed) was conducted, with the search terms: “callosotomy”, “callosal sect*”, “commissurotom*” and “split-brain”. The “commissurotom*” search was further filtered to exclude the cardio vascular “mitral commissurotomy”. The search revealed 933, 350, 345, and 776 articles, respectively, also there was an overlap in the results, which in total gave 1646 unique articles. These were successively screened for IQ data. The reference lists of identified articles were used to locate further potentially relevant studies. A total of 16 studies published between 1969 and 2011 providing data on 87 independent patients/cases (an overview of the included studies can be found in the supplementary material Table S1). All included cases fulfilled the following criteria: (a) numerical IQ data for patients is presented for a time point before (pre) as well as after the surgery (post), or as difference score between pre- and post-surgery scores; (b) the callosal transection was the only surgical intervention between pre and post assessment; (c) the age of the patient was at time of surgery at least 10 years; (d) the provided pre-operational IQ was at least 40 (as the reliability below this level can be questioned); and (e) if more than one surgery was conducted (e.g., a step-wise callosotomy) the data of the first surgery was used. The mean age of the total sample was 23.8 (s.d.: 8.4) years at first surgery (range 10–53 years). The sex of the patients was not always reported (missing in 35 of 87 cases), preventing a systematic analysis of a potential sex differences [7].

2.2. Dependent variables of interest

Full-scale IQ (fsIQ), verbal IQ (vIQ), and performance IQ (pIQ) were considered as variables of interest. For all but three of the included studies, it was possible to verify that intelligence test were applied that used a test norm with an expected mean of 100 and a standard deviation of 15 IQ points. (i.e., any version of the Wechsler Adult Intelligence Scale, Wechsler-Bellevue test, Wechsler Intelligence Scale for Children, Stanford Binet test, Ottawa Wechsler test). For one study T-scores were provided, which were transformed to the IQ scale using linear transformation. For two further studies, it was not possible to determine the exact test that was used, but the range of data presented or previous publications of the same group allowed to assume that also here the standard IQ norm was applied. For details see supplementary material Table S1.

An overview of the final sample size and number of studies per IQ score type can be found in Table 1. As not all articles provided both subscale and fsIQ data for the studied patients, and vice versa, the samples were not fully overlapping. Thus, where only subscale scores were available, we additionally estimated fsIQ (efsIQ) by averaging vIQ and pIQ scores for these subjects, and added this data to the fsIQ. However, it has to be noted that due to the separate transformation of raw test scores to the norm-deviation IQ scores for raw full and subscales [28], respectively, the average rank position (i.e., the mean of vIQ and pIQ) will not necessarily be equivalent to the rank in fsIQ or the full scale. Thus, the efsIQ scores can only be seen as an approximation of fsIQ and has to be interpreted with caution. Nevertheless, efsIQ was considered here in order to utilise as much data as possible and increase the sample

size. Finally, for each of the four IQ scores, change scores were determined by subtracting the pre-surgery IQ from the respective post-surgery IQ, henceforth referred to as Δ fsIQ, Δ efsIQ, Δ vIQ, and Δ pIQ. Positive pre-post change scores represent an increase and negative score a decrease in IQ. The change scores served as dependent variables in the statistical analysis.

2.3. Statistical analysis

Four IPD meta-analyses were conducted for each of the four dependent measures: Δ fsIQ, Δ efsIQ, Δ vIQ, and Δ pIQ. Each meta-analysis was set up using a one-stage analysis approach based on linear-mixed models [3]. The factor Source Study was modelled as random effect to account for between-study heterogeneity, and the variables of interest were modelled as fixed effects, whereby the variables of interest were conceptualized as two-factorial design with Pre-Surgery IQ (coding above or below median pre surgery IQ) and Type of Section (partial vs. complete section), and the interaction of these two variables. Effect coding was employed so that intercept of each model represents the mean pre-post change across groups. All analyses were calculated using restricted maximum likelihood estimations (full covariance matrix; Cholesky parameterization) and fitted with the “fitlme” function provided with MATLAB (R2015b, MathWorks). Significance threshold was set to $\alpha = 0.05$. Effect sizes were calculated as proportion of explained variance (e.v. = [sum of squares effect]/[total sum of squares]) based on the fixed effect sum of squares. The proportion of the variance explained by the random effects variable was taken as measure of inhomogeneity among studies (I^2). The analysis was supplemented with test power calculations using G*Power software (version 3.1) to estimate sensitivity (i.e., the minimum population effect size which can be reliably excluded with a test power of 0.80, given the present statistical design, sample size, and α -threshold) for the fixed-effect part. Of note, as the here re-analysed IQ data is not object of the original analysis and rather is reported as information of the patient, no systematic file-drawer bias should be expected.

3. Results

In none of the four analyses, a significant change in IQ from pre- to post-surgery was found (for the intercept all $p > 0.32$; see Table 2 for details). However, considering pre-surgical performance level, a significant difference in the change of pIQ was found between the below and above median group as indicated by a significant main effect of Pre-Surgery IQ ($t(72) = 2.77$, $p = 0.007$, e.v. = 0.11; see Fig. 1 left panel). The Δ pIQ did not only differ between the two groups, in the above median group the observed mean decrease in performance of Δ pIQ = -5.44 was also significant by itself, with $CI_{95\%} = [-8.33; -2.56]$ not including zero. The mean Δ pIQ of 1.01 observed in the below median group was not significant ($CI_{95\%} = [-1.83, 3.86]$). For neither Δ vIQ nor the full-scale IQ measures (Δ fsIQ, Δ efsIQ), a comparable effect was detected (all $p > 0.08$, all e.v. < 0.05, see Fig. 1 and Supplementary Fig. 1). The main effect of Type of Section (all $p > 0.17$, all e.v. < 0.03) and the interaction (all $p > 0.33$, all e.v. < 0.01) did not reach significance for any of the dependent variables (for details see Table 2). The power analysis yielded a sensitivity of 0.08 proportion of explained variance for the Δ pIQ and Δ vIQ analyses, and of 0.10 and 0.07 for the Δ fsIQ and Δ efsIQ analysis, respectively, so that population effects above these values can be reliably excluded by the present analysis.

4. Discussion

The main finding of the present analysis is that callosotomy selectively affects performance IQ scale whereby the severity of the effect is modulated by the pre-surgical level of performance. In the above-median pre-surgery pIQ group a significant average decrease of 5.44 IQ

Download English Version:

<https://daneshyari.com/en/article/8841848>

Download Persian Version:

<https://daneshyari.com/article/8841848>

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