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THE EFFICACY OF LANGUAGE REHABILITATION THERAPY:

A META-ANALYTIC REVIEW OF TRAUMATIC BRAIN INJURY AND STROKE COGNITIVE REHABILITATION LIERATURE

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THESIS APPROVAL PAGE

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ABSTRACT

The Efficacy of Language Rehabilitation Therapy

Zachary Miklos

This meta-analysis evaluated 10 studies of language rehabilitation and recovery that were conducted after a patient endured a traumatic brain injury or stroke. The primary purpose of this meta-analysis was to determine the overall effect size across these studies and to assess the significance of this aggregate effect size. Results indicated a significant effect size in the control conditions ($r = .3$, $p < .05$) in which patients received no rehabilitative therapy. A significant effect size was also present in the intervention conditions ($r = .4$, $p < .05$). Results showed that language rehabilitation therapies are effective therapeutic interventions, with significant improvements being shown above and beyond what could attributed to the passage of time.

Keywords: language, cognitive rehabilitation, neurorehabilitation, TBI, stroke, meta-analysis

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Introduction to Brain Injury

According to the Center for Disease Control (CDC), traumatic brain injury (TBI) is a contributing factor to 30.5% of all injury-related deaths in the United States. Wu et al. (2013) state that the pathophysiology of TBI is complex and involves both primary damage (e.g., injuries that occur at the time of injury) and secondary damage (e.g., injuries that are initiated but do not appear clinically for hours or days after the injury). Children aged 0-4 years old, adolescents aged 15-19 years old, and adults over the age of 65 years old are the most likely age ranges to sustain a TBI (CDC, 2012). In each of these age ranges, males have a higher prevalence rate than females (CDC, 2012). Karver et al. (2012) state that brain injury in children is a primary underlying cause of long-term and troubling behavior difficulties, with persisting symptoms related to attention deficit/hyperactivity disorder, externalizing behavior problems, executive dysfunction, and social competence deficits.

While there are many causes of TBI and mild traumatic brain injury (mTBI), McNally et al. (2013) suggested that the outcomes associated with these injuries are poorly understood. Numminen (2011) stated that the heterogeneity symptoms associated with brain injury relates to the wide range of conditions one must assess when diagnosing an individual with TBI. While somatic symptoms frequently vary from individual to individual, headaches are the most common symptom of TBI (Patil et al., 2011). Faux and Sheedy (2008) found that 15.35% of individuals who sustained a mTBI complained of a posttraumatic headache, with a significant proportion of these individuals suffering headache symptoms for longer than three months.

In the United States, the social consciousness of brain injury has been on the rise for multiple reasons. One of these reasons is due to the influx of soldiers returning home since the invasion of Afghanistan with war-related bran injury; Taylor et al. (2012) stated that TBI is the “signature injury” for soldiers in the Operation Enduring Freedom and Operation Iraqi Freedom campaigns. A second reason for this increased social interest is due to the National Football League (NFL) increased its interest in preventing concussion and TBI. Allen and Gfeller (2011) reported that concussions occurring in all sporting contexts range from 300,000 to 1.54 million mild-to-moderate brain injuries per year. Slobounov, Gay, Jonhson, and Zhang (2012) reported that over the past ten years the annual rate of diagnosed concussions increased by 16.5% annually amongst high school athletes. Third, the social awareness of brain injury has also grown along with an aging “baby boomer” generation. Because the complications brought about by a brain injury in a geriatric population are so numerous, it is important to identify and develop specialized treatments for these older individuals (Uomoto, 2008). Yet despite this growing research base, the consequences and treatment of brain injury remains largely enigmatic due to the individualized nature of neuroanatomy.

To serve this large afflicted population, neurological research has proliferated in areas such as memory, language, attention, and emotional disturbances. McNally et al. (2013) discussed a controversial debate developing in the neurological community regarding the etiology of postconcussive symptoms (PCS). The “psychogenesis group,” argues that PCS is not related to alterations in brain functioning but rather results from premorbid differences, postinjury psychological factors, and/or malingering (McNally et al., 2013). Conversely the “physiogenesis group” argues that PCS is related to changes in brain function that occur following a TBI or mTBI (McNally et al., 2013). While these two sides do conflict regarding the causal factors that underlie behavioral disturbance after brain injury, their positions are not mutually exclusive because both injury and noninjury-related factors predict the variety of neurobehevaioral outcomes following TBI or mTBI.

Treatment for brain injury has been conceptualized by some as a continuum of care, with individuals frequently entering, exiting, and re-entering treatment at any one of multiple potential entry points during the course of a head injury (BIAA, 2013). A number of facilities and program types are available for head injured individuals such as intensive care units, outpatient therapy, day treatment, or medicinal therapy (BIAA, 2013). However, there is considerable variability in terms of the type of treatment regimens a survivor undergoes in their programs.

Introduction to Stroke and Aphasia

On average, one United States citizen dies from a stroke every four minutes (CDC, 2012). D'Allessandro et al. (2010) stated that stroke is one of the main causes of mortality and disability in industrialized countries, with the incidence of stroke likely to rise due to the "baby boomer" generation aging. Persson, Parziali, Danielsson, and Sunnerhagen (2012) stated that the history of individuals with stroke has changed in recent years, specifically from 1995 to 2008, with the common characteristics of stoke survivors being that they are more likely to be single, living at home, needing more in-home assistance, and present with a better functional status prior to stroke. Primary care at the individual and population level has become more common because hospital acute stoke units now include rehabilitation units, team meetings, and discharge planning (Persson, Parziali, Danielsson, & Sunnerhagen, 2012).

Aphasia is one of the most common neurological symptoms after stroke (Bakheit et al., 2006). Bakheit et al. (2006) reported that between 30-45% of post-stroke aphasic individuals will not recover. While obvious deficits exist in language ability, Vickers (2010) stated that attitudinal and environmental barriers caused social inhibition and social exclusion after stroke. While there is a plethora of research on aphasia, Beveridge and Bak (2011) found that 62% of all research is done on English speaking aphasic patients and less than 8% of aphasia-related research relates to non-Indo-European languages. Beveridge and Bak (2011) reported that the current state of aphasia literature is dramatically unrepresentative of the world's languages. Clearly, effective therapeutic interventions for aphasic stroke patients require a better understanding of different types of languages and their impact on aphasia (Bakheit et al., 2007).

In addition to aphasia, stroke patients present with heterogeneous symptoms; Depression (Glymour et al., 2012), vascular risk factors (Tennen et al., 2011), physical impairment and fatigue (Lerdal et al., 2011) and a variety of language related disorders. The recovery process usually includes environmental, motoric, and/or somatosensory enrichment that is designed to capitalize on the brain's "neuroplasticity" (Särkämö et al., 2008).

Cognitive Rehabilitation of Language

Language treatment for brain injury and stroke is diverse and varied. The variability in treatment stems primarily from the variability in the disciplines that contribute to the field. As neurological and neuropsychological techniques become more refined, speech-language pathologists, psychologists, neurologists, and a number of other medical professionals are developing new evaluation and rehabilitation techniques designed to enhance brain injury and stroke language rehabilitation. For example, Turkstra (2008) described a "Video Social Inference Test" to assess how individuals with brain injury socialize in daily conversations. Kirmess and Maher (2010) proposed a constraint induced therapy that focuses on improving acquired language deficits after stroke. Conklyn, Novak, Boissy, Betoux, and Chemali (2012) described a melodic intonation therapy that helps individuals with nonfluent aphasia to regain language abilities via combining melody with words in order to facilitate speech output. Each of these individualized therapies has specific treatment outcomes, is designed for specific clinical populations, and focuses on rehabilitating different brain mechanisms to facilitate recovery.

A second reason for these diverse language treatments is due to the nature of brain injury. Because the brain is such a unique organ for every person, injury results in a multitude of possible neurological complications. The intricate interplay of neuroanatomical structures and neurotransmitters becomes dysregulated with brain injury or stroke and can produce a variety of different behavioral or cognitive abnormalities. While Broca's and Wernicke's areas are the brain regions typically researched in regards to language (Fecteau, Agosta, Oberman, & Pascual-Leone, 2011; Fridriksson et al., 2012; Kemmerer, 2012; Konrad, Vucurevic, Musso, & Winterer, 2012), these are not the only neuroanatomical regions implicated in brain injury and stroke. Grey and white matter (Josephs et al., 2012), the left inferior frontal cortex (Poeppel, Emmorey, Hickok, & Pylkkänen, 2012), and the peri-Sylvian area (Meguro, 2012), are all neuroanatomical language areas being studied.

Language Rehabilitation Efficacy

Cognitive rehabilitation after brain injury and stroke has been a topic of interest in a number of reviews assessing efficacy of treatment (Cicerone et al., 2000; Cicerone et al., 2005; Robey, 1998; Rohling et al., 2009; Wisenburn & Mahoney, 2009). In a systematic review conducted by Cicerone et al. (2000), 171 articles assessing cognitive rehabilitation literature were reviewed. These 171 articles were broken into seven categories (attention, visual perception and constructional abilities, language and communication, memory, problem solving and executive functioning, multi-modal interventions, and comprehensive-holistic cognitive rehabilitation) reflecting the articles primary intervention focus. These 171 articles were further divided using their level of evidence based on the recommendations of the Cognitive Rehabilitation Committee (Cicerone et al., 2000). The Committee defined three separate classes of studies: Class I, Class II, and Class III studies.

Class I studies were defined as well-designed, prospective, randomized controlled trials. A subdivision of Class I studies were Class Ia studies which the Committee defined as "featur[ing] a prospective design with 'quasi-randomized' assignment to treatment condition, such as prospective assignment of subjects to alternating conditions. Class II studies were defined as consisting of "prospective, nonrandomized cohort studies; retrospective, nonrandomized case-control studies; or clinical series with well-designed controls with well-designed controls that permitted between-subject comparisons of treatment conditions." Class III studies were defined as being "clinical series without concurrent controls, or studies with results from 1 or more single cases that used appropriate single-subject methods, such as multiple baseline across interventions with adequate quantification and analysis of results."

Cicerone et al. (2000) found clear evidence that cognitive rehabilitation facilitated recovery in individuals with TBI and stroke. The moderator variable treatment domain was found to be significant, $Q(4) = 29.09$, $p < .001$, as well as the cognitive treatment domain, *ES* ($p < .02$). Study Class (I, II, and III), etiology (TBI vs. stroke), treatment duration, and recovery stage were all nonsignificant moderators (*ps* > .26). Regarding language treatments, Cicerone et al. (2000) recommended that interventions directed at improving pragmatic communication and conversational skills provided significant benefits to individuals with TBI. A second recommendation from Cicerone et al. (2000) regarding language treatment was for the use of cognitive interventions targeted at reading comprehension and language formation which also provided significant benefits to individuals with left hemisphere stroke or TBI.

In an update of Cicerone et al. (2000) and Cicerone et al. (2005)'s studies, Rohling et al. (2009) evaluated 115 distinct studies that were derived from Cicerone et al. (2000) and Cicerone et al. (2005)'s original studies. Rohling et al.'s (2009) selected studies included 70 single-group pre-post (SGPP) designs and 45 independent groups pre-post (IGPP) designs. Exclusionary criteria used by Rohling et al. (2009) but *not* Cicerone et al (2000) and Cicerone et al. (2005) include removal of single-case studies or multiple case studies with a total sample size less than three ($N < 3$), due to meta-analytic methods requiring a sample size greater than four in order to adequately estimate variability (Rohling et al., 2009), as well as removal of studies that did not provide sufficient statistical information to calculate a mean difference. Rohling et al. (2009) also looked at potential moderator variables such as etiology, recovery level, and mean age of patient samples. The authors concluded that cognitive rehabilitation for attention, visuospatial, and language produced significant improvements while memory treatments produced vague results and comprehensive treatments failed to produce a significant improvement.

Regarding language treatment efficacy, Rohling et al. (2009) found small but significant effect sizes for SGPP's ($p < .05$) and IGPP's ($p < .01$). The authors concluded that not enough language rehabilitation literature exists that includes outcome measures to provide estimates of treatment effects; that is, there was not sufficient published research that *specifically* addresses language rehabilitation treatments. In fact, only four of Rohling et al. (2009)'s articles discussed language treatments after TBI. While Cicerone et al. (2000) claimed that there is a strong body of evidence supporting the benefit of cognitive rehabilitation for TBI and stroke, Rohling et al. (2009) provided weak support for this claim, especially regarding language treatment. With this in mind, Rohling et al. (2009) stated that it is difficult to make a conclusive argument about the benefit of cognitive rehabilitation on language until more treatments are developed that target language deficit rehabilitation.

Meta-Analysis and Effect Size Measures

A meta-analysis is a statistical analysis of a collection of previously published literature for the purpose of integrating their findings. The goal of a meta-analysis is to assess the overall effect sizes of specific variables in previously published literature. An effect size is the magnitude and direction of the difference between two groups or the relationship between two variables (Durlak, 2009). Effect sizes provide an assessment of the shared correlation between independent and dependent variables. Homogenous collections of effect sizes indicate consistent relationships across studies (Rohling et al., 2009). There are several different ways to evaluate effect size however, generally, overall effect sizes across studies are significant if they differ statistically from zero. Berben, Sereika, and Engberg (2012) state that rules of thumb for effect sizes in behavioral sciences are: small = .10, medium = .30, and large = .50.

METHODS

Sample of Studies

The present study is a meta-analytic review of rehabilitative language studies that have been published subsequent to the reviews by Cicerone et al. (2000), Cicerone et al. (2005), and Rohling et al. (2009). Studies pertaining to language rehabilitation efficacy were indexed by Medline, PubMed, PsycINFO, and Google Scholar. Studies were selected using the following keywords: “language,” “lang*,” “cognitive,” “rehabilitation,” “rehab*,” “traumatic brain injury,” “TBI,” “stroke,” “aphasia,” “aphas*,” and “treatment.”

Studies were excluded based on Rohling et al (2009)’s criteria: 1) articles not containing a language-rehabilitative intervention, 2) articles that merely describe treatment approaches or theories, 3) other review articles, 4) unspecified or unmeasured interventions, 5) articles lacking diagnosis or assessment of TBI or stroke, 6) case studies of a single participant with no empirical data, 7) non-peer reviewed articles, 8) articles including exclusively-pharmacological interventions, and 9) articles not written in English. Additional criteria not used by Cicerone et al. (2000), Cicerone et al. (2005), or Rohling et al. (2009) excluded articles that did not present the means or standard deviations for groups. In total, ten published language rehabilitation studies met selection standards and could be included in the analysis. Five of the studies compared a treatment intervention to a control group. The other five studies contained a treatment intervention but no control group.

All studies used in this meta-analysis were not used in the meta-analysis conducted by Rohling et al. (2009). Furthermore, some of the studies in this meta-analysis had multiple therapeutic modalities present in the methodology. While ten published studies were used, sixteen cognitive rehabilitation therapies were analyzed. Some of the included studies present two different cognitive rehabilitation therapies in the same article, e.g. Bakheit et al. (2007) compares an intensive therapy group to a standard therapy group *and* a comparison of therapy given by National Health Service therapists to a standard therapy group.

Procedural Analysis

Effect sizes (ESs) were computed from the available statistics in each of the published studies using the MIX 2.0 Microsoft Excel software package. These ESs (calculated as correlations, *r*) were analyzed to determine whether or not the average ESs were significantly different from zero. ES’s from the studies’ control conditions estimated how much language improvement was attributable to the passage of time. The ES’s from intervention conditions were analyzed and used as an estimate to how much language improvement could be attributed to cognitive rehabilitation therapy and from the passage of time. A second analytic procedure involved comparing the control conditions ES's to the experimental to determine whether cognitive rehabilitation interventions yielded significantly larger ES's compared to the control conditions. A third analytic procedure involved comparing the control and experimental conditions differences to the differences found in the language studies used by Rohling et al. (2009). A final analytic procedure involved calculating Begg's test statistics in order to measure dissemination bias, or the extent to which the studies overestimate the ES.

RESULTS

Control Conditions Analysis

The average ES for control conditions was significant ($r = .27$, $p < .05$), CIs [.21, .32]), indicating a significant improvement in language which occurred simply due to the passage of time since the injury occurred. This effect was originally documented in Rohling et al. (2009), $r = .3$, $p < .05$, CIs [.24, .35], and replicated here. Figure 1 is a forest plot displaying the ESs, expressed as correlations, for all included studies in the control condition. Figure 2 is a forest plot displaying the ESs, expressed as correlations, for all of the included language studies used by Rohling et al. (2009). The horizontal lines that pass through the data points in each plot are the confidence intervals for that ES. The extent to which the horizontal lines overlap indicates the homogeneity of the ESs across studies.

The forest plots in Figure 1 shows that the studies were generally homogeneous, with three studies showing smaller effects (less than .3) and three studies showing effects greater than .4. The forest plot of the Rohling et al. (2009) study also was generally homogeneous. Analysis of the ESs in each study indicated that there was a significant overall effect in each study, but the average ESs in these studies did not differ significantly ($p > .05$) from each other.

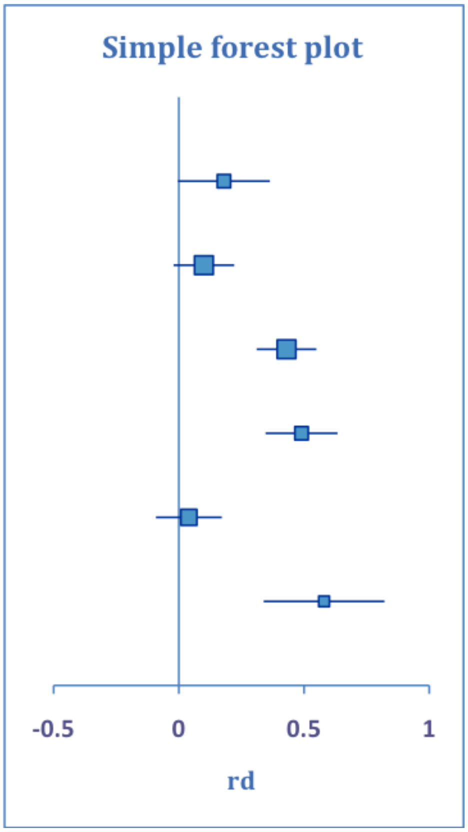

Figure 1. Forest Plot of ESs in Control Group Studies

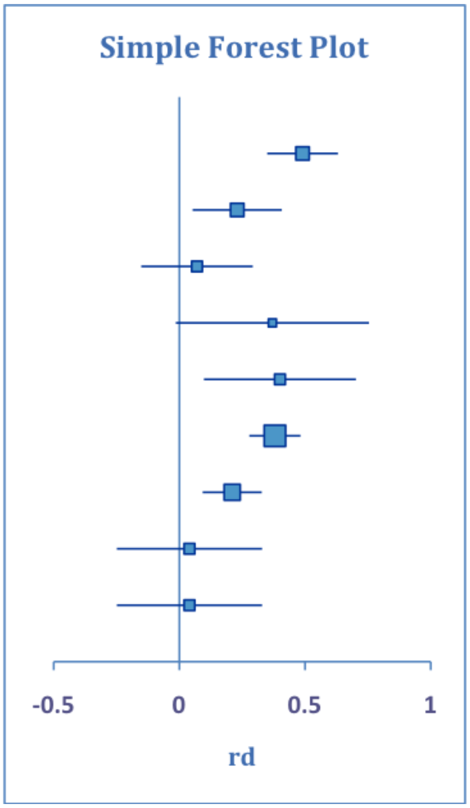

Figure 2. Forest Plot of ESs in Rohling et al. (2009)'s Language Control Group Studies

Begg's Test statistic was computed on these ESs in order to determine whether publication bias affected the results. The Begg's Test statistic was not significant (p = .85) indicating that publication bias was not present in the studies. Funnel plots are typically used to demonstrate dissemination bias. Because the dots are distributed randomly around the synthesis estimate line depicted in Figure 3, the plot does not indicate any dissemination bias. Figure 4 also shows a lack of publication bias in Rohling et al. (2009)'s studies as well (p = .59).

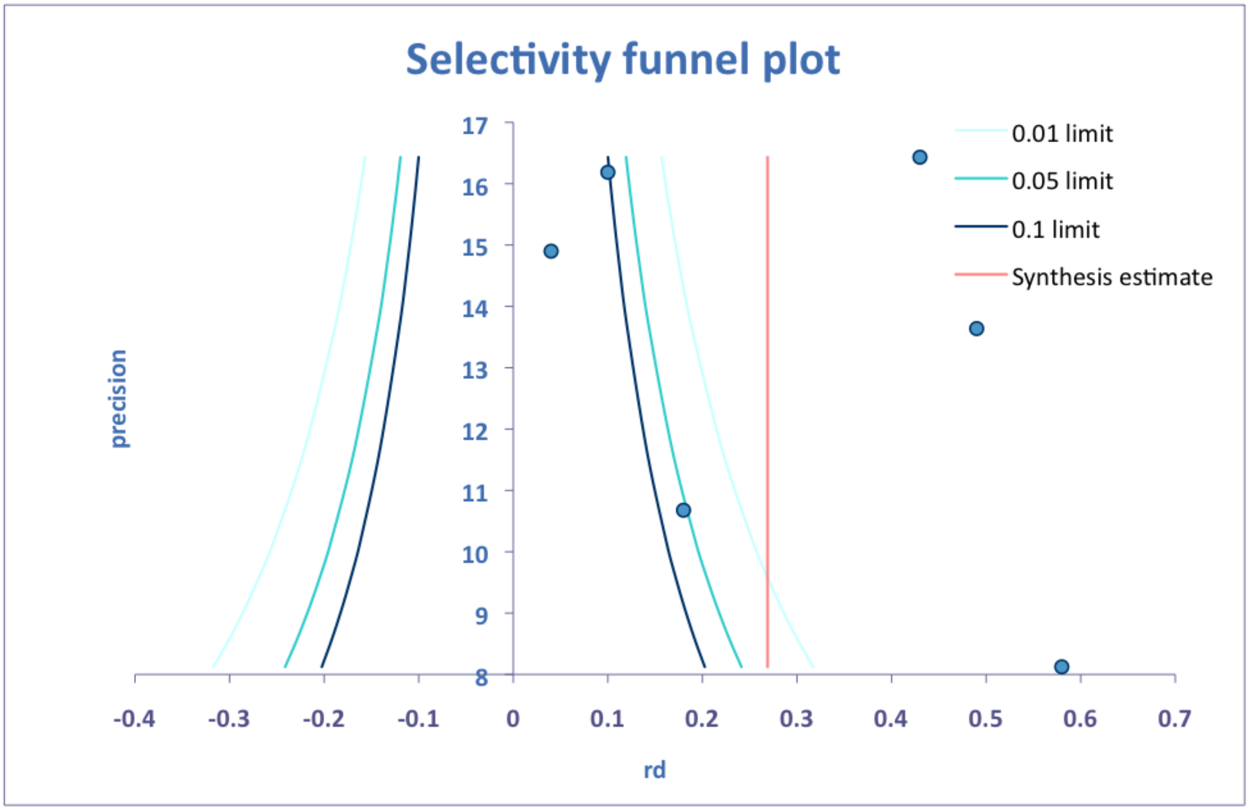

Figure 3. Funnel Plot for Control Group Studies

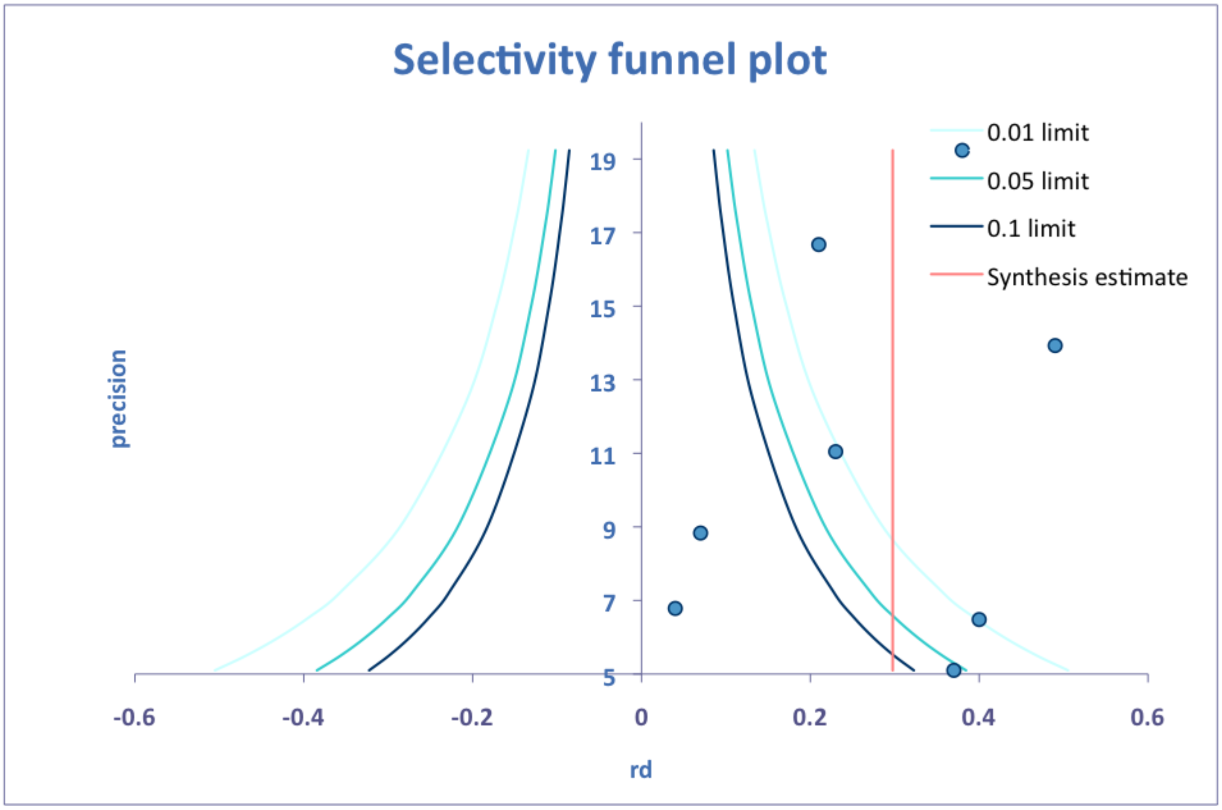

Figure 4. Funnel Plot for Rohling et al. (2009)'s Language Control Group Studies

Intervention Conditions Analysis

The average effect size for intervention conditions in this study was significant (r = .40, p < .05), CIs [.34, .45]), the confidence interval for the ES did not contain a zero which indicated a significant improvement in language with treatment. Relative to the control conditions above, the fact that the confidence interval for the average ES across intervention conditions did not contain the average ES in for the control condition suggests that some amount of the intervention ES could not simply be attributed to the passage of time. . This effect was originally documented in Rohling et al. (2009), r = .35, p < .05, CIs [.29, .41], and replicated here

Figure 4 is a forest plot displaying the ESs, expressed as correlations, for all included studies in the intervention condition. Figure 5 is a forest plot displaying the ESs, expressed as correlations, for all of the included language studies used by Rohling et al. (2009) in the intervention conditions.

The confidence interval computed around the ESs in the present study contained the average ES originally for the language studies reported by Rohling et al. (2009). Although the average ES was somewhat higher in the present study compared to Rohling's et al. (2009)'s average language ES, there was no significant difference found between the two ($p > .05$). However, the aggregate ESs for experimental conditions in both reviews were significantly larger than those obtained in the control conditions. This difference suggests that the experimental treatments produced significant and robust improvements in cognitive functioning over and above the simple passage of time.

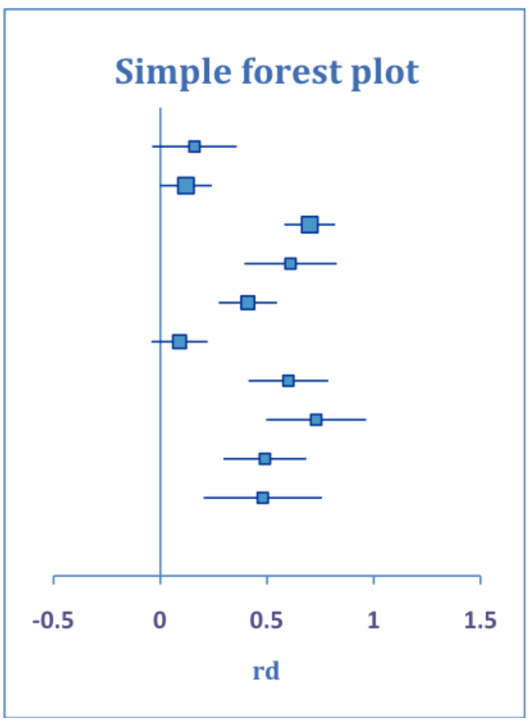

Figure 5. Forest plot of ESs in Intervention Group Studies

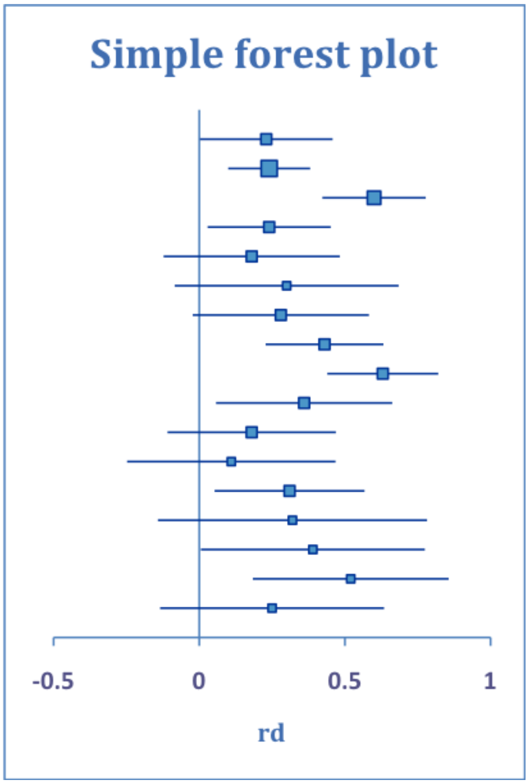

Figure 6. Forest Plot of ESs in Rohling et al. (2009)'s Language Intervention Group Studies

Begg's Test statistic was computed in order to determine whether publication bias was present in the sample of studies used. The Begg's Test statistic was not significant (p = .53) indicating that publication bias was not present in the current set of studies. Figure 7 shows a distribution of studies that is distributed randomly around the synthesis estimate line indicating lack of publication bias. This same pattern is present in Rohling et al. (2009)'s studies as well (p = .90, see Figure 8).

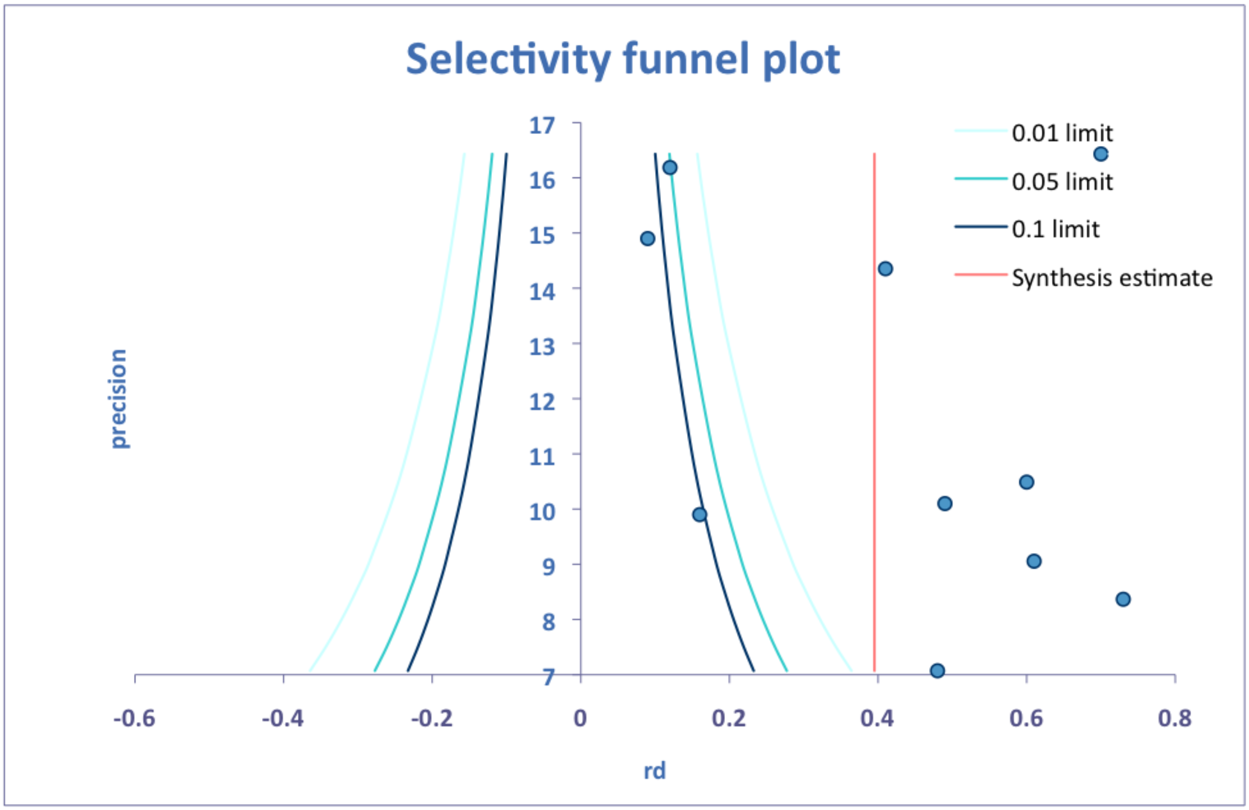

Figure 7. Funnel Plot for Intervention Group Studies

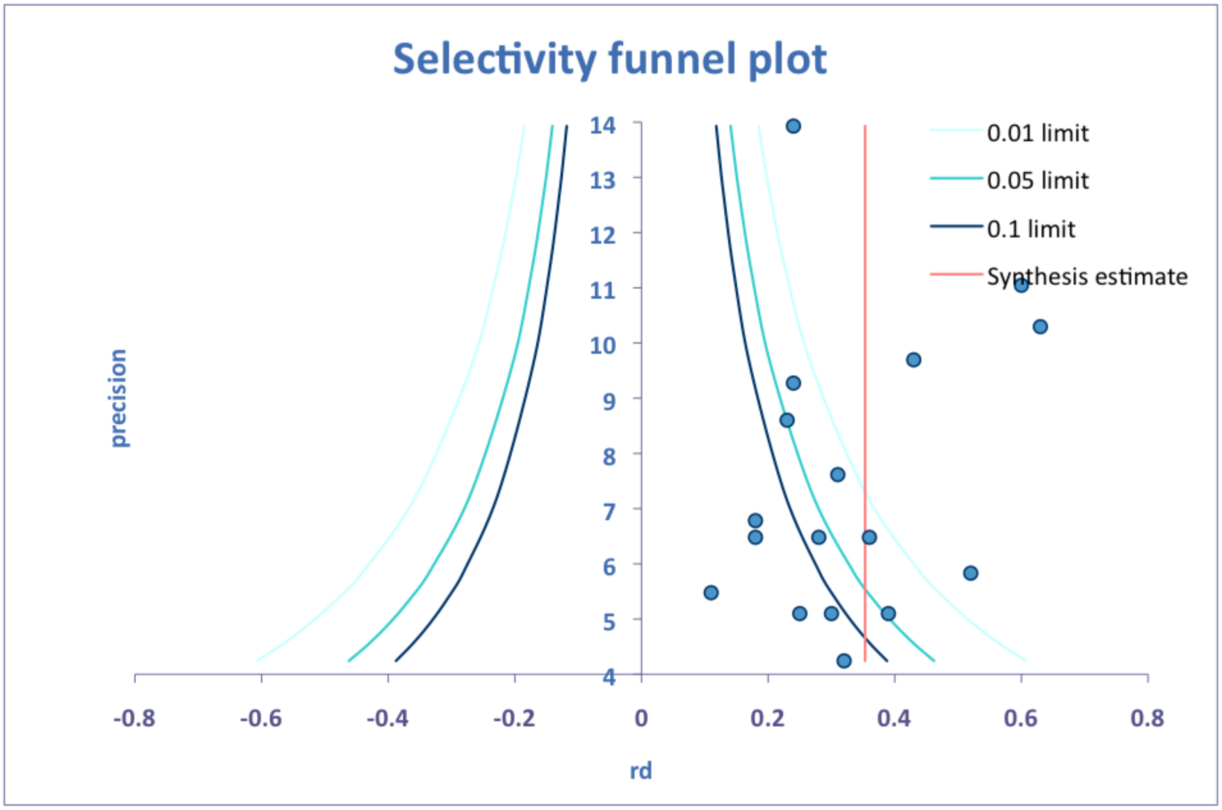

Figure 8. Funnel Plot for Rohling et al. (2009)'s Language Intervention Group Studies

DISCUSSION

Consistencies and Curiosities

The present study generally replicates Rohling et al. (2009), with both reviews showing that language intervention improves cognitive functioning after TBI and stroke. Both meta-analyses show a small but significant ES that occurs with the passage of time although both also show an ES for the intervention groups that was significantly larger than was found in the control condition. The difference between these ESs suggests that somewhere between 5 and 13 percent of the effect that occurs in intervention studies results from the intervention itself whereas the remainder of the ES results from spontaneous change.

These data also show a slightly larger ES for more recent studies relative to those reported by Rohling. This finding replicates other meta-analyses that showed similar differences in these patient populations (Bernard, 2009; Elliott, 2013). Another consistency concerns the lack of publication bias in these data and in Rohling et al. (2009)'s published work. There is little evidence of unpublished data that would disclaim these findings. Regarding the set of interventions that were used in these studies, the effects are clear: language intervention produced an effect that was significantly larger than what occurred without intervention, while a small though significant amount of improvement occurred spontaneously.

There are several limitations to the conclusions derived from this or any other meta-analysis of CRT studies. The first involves the general lack of usable studies. Because most of the investigators and clinicians who do research in this field are not trained researchers, the data available largely derive from pre-existing records, practice files of a single therapist, case studies, and self-report. There are few clinical trials and even fewer pre-planned studies that contain appropriate control groups. A possible explanation for this concerns the ethical considerations that make many experimental manipulations and withholding treatments unfeasible. Therefore, for a variety of valid reasons, the ratio of well controlled to quasi-experimental studies is small and it is difficult to find studies that are specifically focused on cognitive rehabilitation therapy. The present study could have included more studies if it reduced the inclusion criterion however, the author opted to draw conclusions from a smaller number of better studies rather than to risk conclusions that were based on a larger number of studies with limited internal validity. The lack of publication bias present in the present study and in Rohling et al. (2009)'s validates this strategy; the consistency of conclusions drawn from both data sets suggests that the ESs are stable and replicable.

These results are also limited to studies of patients with two types of disability, stroke and TBI. However, language disorders result from a number of maladies, e.g., dementia, schizophrenia, developmental disorders, progressive degenerative diseases, etc. It is therefore likely that the effects of cognitive rehabilitation therapy might differ in relation to the nature of the patient's unique medical condition.

A further problem with this line of inquiry is that there is no consistent definition of cognitive rehabilitation therapy, which makes it difficult to replicate the treatment interventions. Even in well-controlled studies, it is often difficult to determine exactly how a treatment was administered. This issue is part of a larger problem in the field of cognitive rehabilitation therapy. There is a lack of standardized treatments that can be evaluated for efficacy. Instead, most cognitive rehabilitation therapies involve vague descriptions of interventions that are difficult to replicate. It is very difficult to accurately determine what is and what isn't a cognitive rehabilitation therapy.

A final problem with research in this field is lack of formalized criteria regarding the extent of the brain injury or stroke. Often a patients injuries are complicated by a variety of ancillary disorders, psychiatric problems, varying medication regimens, or predisposing conditions that all coalesce to limit their cognitive functioning and delay their recovery. These problems are seldom discussed in research publications. This makes it difficult to match patient populations in future studies. An exception to this statement is the definition of concussion, i.e., a mild brain injury. In 1997, the Quality Standards Subcommittee defined a concussion as "any trauma induced alteration in mental status that may or may not include a loss of consciousness" (p. 582). Lack of formalized definitions such as this makes defining injury type vary from individual to individual.

Recommendations for Future Research

The present results lead to several recommendations for future research. Because meta-analysis provides an overview of a specific content area, it is reasonable to suggest that an ongoing update of the data from published studies should be undertaken to continually study changes in the field and to evaluate the efficacy of interventions. As a step in this direction, the present study includes its database in the hope that other researchers will add to it and draw conclusions from it. Consistently updating a shared database would provide all researchers with the most accurate and easily accessible data for an ongoing meta-analytic of language rehabilitation research.

The review of this literature also indicates a need for developing consistent criteria for cognitive rehabilitation interventions along with standardized treatment batteries that can be applied consistently across studies. An example of such a standardized treatment is the Attention Process Training program developed by Sohlberg and Mateer (1986). Sohlberg and Mateer (1986)'s training program has proven efficacy and, because it is standardized, can be used as a model for training attention. Developing this type of standardized intervention for training language skills would be especially helpful to proliferate new articles in this field and to expand on the results of this study.

Furthermore, the research database also indicates a need for evaluating different covariates that may determine treatment efficacy. As mentioned previously, the type of disorder, patient history, predisposing conditions, education, medication regimen, the extent of the patients' family support structure, ability to live independently, consistency of therapy after the TBI or stroke, and a litany of other covariates all may influence a cognitive rehabilitation treatments outcome. However, few of these variables have been evaluated systematically.

Therefore, a comprehensive meta-analysis would allow for evaluation of all of these covariates as potential determinants of overall effect size.

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