Left-handedness in Special Education:

A Meta-Synthesis

Vera B. Kinzer

Submitted in partial fulfillment of the requirements of the Master of Education in

Special Education degree at the University of Alaska Southeast

RECOMMENDED: _____
Jill Burkert, Ph.D., Academic Advisor

APPROVED: _____
Deborah Lo, Ph.D., Dean, School of Education

_____

Abstract

Left-handers are disadvantaged, but despite the fact that universal design favors right-handedness, left-handedness may be associated with cognitive advantages. Left-handedness is considered a fairly normal human condition that has persisted throughout history, and is currently represented in about 10% of the population. Our modern idea regarding hand preference is rooted in the split-brain theory, which involves the contra-lateral control of the left and right hemispheres over opposite sides of the body. Technology has advanced brain research about handedness and brain organization, and this research should help advance early recognition and more successful intervention in the areas of a student's behavior, learning disorder, and/or other health impairments (that affect their brain functioning, such as traumatic brain injury or fetal alcohol syndrome disorder). This meta-synthesis is an analysis of the literature on left-handedness: It is an attempt to answer whether left-handedness is relevant in special education today.

1. Introduction

1.1. Background

Our left-handed roots go back as far as the cave: Left-handedness is evident in pre-historic artifacts. Anthropologists examining Neanderthals' teeth were able to determine which hands held bones more often, and consequentially, the percentage of left-handers in the population. In *The Left-Handed –Their Sinister History,* the author provides a vivid description of left-handedness through history. Left-handedness occurs in 10% of the population (the same rate as in pre-historic times), despite a favorable environment for right-handed people. The attitudes towards preferential use among most societies down through the ages have largely been biased against left-handedness, especially in the areas of tool and weapon design. In the past, it was simply more efficient to design tools and weapons for right-handers since there are significantly more of them in the population. Taking into consideration the bias for right-handed universal design through history, left-handed people seem quite adaptable, and tolerant. And perhaps this has led to modification in their personality and character. Since the sinister association with

left-handedness has been disavowed, the harsh attitude toward “lefties” has considerably softened. Children respected for their left-handed preference, if not a little celebrated. In baseball, for example, ”south paws” can excel, especially pitchers and switch-hitters. Left-handers facing right-handed opponents do have an advantage. In medieval times, spiral staircase escape routes were designed so that the opponents would have a harder time fighting with their right arms. And it stands to reason that the opponents would try to find a left-hander to lead these attacks. So left-handedness does have certain attributes and advantages. But today, left-handed students are lucky if there are left-handed scissors, or a left-handed desk in a classroom. Left-handed students with other disabilities must feel extra frustrations within schools that are intentionally and exclusively designed for right-handed people.

Through the ages, in tool and weapon design, and writing-- left-handedness has been treated negatively. The unnecessarily mean connotations and slurs toward left-handedness, and the bizarre remedies and cruel solutions for left-handedness, have been observed in many cultures. In fact, since left-handedness goes so far back in our ancestry, there must be some genetic benefit to this twist in neuro-diversity. Nowadays, left-handedness isn’t considered much of a problem, (Costas, 1996). Some people even believe that there must be positive traits associated with

left-handedness that can lead to greatness: For example, Leonardo Da Vinci was determined to be left-handed (experts can tell by his shading), and several of our recent presidents were left-handed (Bush, Clinton and Obama). There are also claims that 20% of MENSA members are left-handed. But it is speculation that left-handedness is associated with highly talented people, or deviant people, as some have promoted. Left-handedness has run the gamut, from one extreme side to the other.

Until the mid-20th century, many educators believed left-handed children should be re-trained to use their right hand, even binding the left hand. However, overall IQ and ability was determined to be equal in left and right-handed individuals, and eventually, use of the left hand was accepted in schools. Left-handers can manage a way to hook their hand, and may develop a unique style for writing. By the 1980's, the only educational concern for left-handedness was for writing legibly, and students only received special instruction if it was necessary. Acceptance of left-handedness in schools paralleled the rise of the left-brain/right brain model (from 1950—1980), which in turn was overshadowed by the theory of multiple intelligences. Today handedness provides a special glimpse into how the brain really works, and how the two cerebral hemispheres work together. The model of brain laterality is an approach to understanding the functional organization of the brain

and brain structures. Of special interest is the corpus callosum, which connects the two halves of the brain (Rippon, 1996). The heuristic approach to handedness, and right brain/left brain thinking, is making room for new data on brain lateralization, and theories on how the two hemispheres communicate and work together. Brain research will to enhance our view into a student's thinking world.

The expression of handedness reveals which cerebral hemisphere is dominant. And brain lateralization and cerebral dominance is thought to give rise to different cognitive styles. Robbins (1985) felt the suggestion that counselors should become aware of these cognitive learning styles, and cerebral dominance, in order to profile individuals for employment opportunities and training, and for schizophrenia and depression was premature. Through the use of modern methods such as functioning magnetic resonance imaging (fMRI), the areas of functioning brain tissue critical to certain types of thinking have been identified. For example, language processing and speech is located in the left hemisphere, and visual and spatial skills are located in the right hemisphere. If IQ and mental ability is considered equal in left and right-handed individuals, then the left brain/right brain theory, or spilt-brain theory, falls short of explaining the big picture of brain lateralization. There is more to attributing control of the left hand to the right hemisphere, and control of the right hand to the left hemisphere. And there is more to cerebral dominance then

right-brain thinking and left-brain thinking. For example, a corpus callosum study shows asymmetric communication, from the left to right hemispheres, but not with the same intensity from the right hemisphere to the left hemisphere (Verlager, et. al., 2011). Moreover, left-handedness is considered a continuum of types (Faurie, et. al., 2008). The range of types of handedness in general spans from being completely left-handed to completely right-handed, and that accounts for the existence of mixed-handedness (using different hands for different tasks) and ambidextrous individuals. It could be argued that lateral dominance, also has a range or continuum.

1.2. Author's beliefs and experiences

My experience and interest in left-handedness began early in childhood as my brother was left-handed. I remember that the concern from the nuns at the parochial school we attended during the early 60's seemed over-whelming and wrong. Having a group of important adults attempting to his hand preference for writing must have been traumatic for him. However, my mother intervened in the nuns' plan and my brother was allowed to continue using his left hand for writing. His penmanship developed a smooth, forward slant, as he transitioned from manuscript to cursive, and he had a nice signature too. He died when he was still a teenager, and I no longer recall if he

favored his left hand exclusively, (but I believe so). I do remember how much fun he was; even though he was a quiet kid, there was no better friend or playmate. We built a clubhouse, a tree fort, multiple rafts to float the creek, and our own fishing rods—that actually worked. He wasn't just good at building things, we also acted out comic books stories. He was a very imaginative and creative left-hander. Some of the articles in this meta-synthesis would supportive of that claim. As we grew older, we both became more engaged with our distinct peer groups. My brother was a normal kid in school, an average teenager with lots of friends and normal appetites through school. His only health issue was asthma. In college, my brother studied the relatively new field of computer science in (1971). Unfortunately, we were not allowed to see what would become of my brother professionally or otherwise. I like to believe he would have done well in architecture, using computer –assisted programs. This would be in line with left-handedness and right-brain thinking. Regardless of my brother, have always regarded left-handed people as being incredibly special, although I am biased.

Without much experience in special education, I accepted a teaching position at Whaley, an alternative day school in the Anchorage School District for students with emotional and behavior disorders (EBD), cognitive and other health impairments, (including fetal alcohol syndrome disorder (FASD), which was once speculated to affect 70% of Whaley population). Over the eight years I taught at Whaley, starting with 4th graders and ending with middle school math students, I was noticing a larger percentage of left-handed students in my classrooms than what is normally purported to exist in the general population. When I asked other teachers about the relatively high incidence of left-handedness in special education at Whaley, none of other teachers had the foggiest notion. Moreover, it seemed most teachers didn't take note their students' hand preference.

By the time I had completed my certification in special education, I had still not found references to handedness in the certification program. I

found the same thing in my regular education coursework. Handedness, specifically left-handedness, seems to have been ignored by education. However, it seemed likely to me that there was a reason for seeing so much left-handedness in this separate day school (for special education students with emotional and behavioral disorders (EBD).

Left-handedness occurs in about 10% of the US population, (Costas, 1996). I believe the prevalence of my left-handed students at Whaley, over eight years, usually ran between 20% to 50%. However I did not keep records, and it would be hard to prove these figures now. After working in that population for eight years, I still believe left-handedness to be of significant interest. After moving to the hospital setting, working with students in acute and residential pyschiatric care, I continue to see elevated numbers of left-handed students. Despite our current trend to minimize its importance, I believe handedness could be an important piece of information, a clue, or indicator, to include in a

child's IEP. I am curious if handedness could be used as a marker for brain development, and perhaps mental health in young children.

1.3. Purpose of this meta-synthesis

The meta-synthesis focuses on the science of left-handedness, and it has three basic purposes:

1. What is the research on left-handedness?
2. Is there a relationship between left-handedness and behavior, learning disorders and disabilities?
3. What are the implications of left-handedness for special education?

The ultimate purpose is to improve the delivery of instruction to left-handed students and accommodate their unique learning style and needs by exploring the research outlined here, and to gather new perspectives on an over-looked characteristic—left-handedness. Hand-dominance is observed as early as eight months, and grasping is observed in the first year, (Butterworth, 1992). If handedness is a viable marker for developmental disorders in children, then they could receive earlier diagnosis, treatment and instruction. The functional asymmetry of the two halves of the brain, cerebral dominance and the neurological lateralization leading to left-handedness is complicated and the theory needs careful

explanation, (Geshwind, & Galburda, 1985). My meta-synthesis is not meant to describe left-handedness in great neurological detail, but enough to satisfy my curiosity whether left-handedness is increased in the special education setting.

2. Methods

2.1 Selection criteria

The articles included in this meta-synthesis met the following criteria:

1. The articles were concerned with handedness and brain laterality;
2. The articles were concerned with brain structures and functions;
3. The articles were concerned with the advancement of brain research;
4. The articles were published from 1972—2014;
5. The articles were peer-reviewed.

2.2 Search procedures

Database searches were conducted to locate articles for this meta-synthesis.

2.2.1 Database searches

I conducted searches in ERIC, Ebscohost (Educational Resources Information Center), Teacher Reference Center, Psychology and Behavioral Science Collection, PyschArticles, and PsycINFO using search terms:

1. “left-handed”, “right-handed” and “behavior”
2. “atypical handedness”, “schizophrenia”
3. “fetal origins”, “non-right handedness”, and “mental health”
4. “lateral dominance”, “behavior disorders” and “children”
5. “left brain”, “right brain” and “behavior”
6. “history” “left-handed” and “attitudes”
7. “handedness”. “behavior” and “attitudes”

2.2.2 Ancestral Searches

An ancestral search yields references to topics of interest to previously published works. An ancestral search was conducted to compliment the original search for related articles (Geshwind & Galaburda, 1985). I conducted the ancestral search using the reference list of the previously retrieved article. The search yeided one additional article (Geshwind & Galaburda, 1985), which was part two of a three-part series of articles by the same authors.

2.3 Coding Procedures

Each article was coded according to publication type, research design, participants, data sources and findings.

2.3.1 Publication Types

Each article was categorized as to publication type (e.g. research study, theoretical work, descriptive work, opinion piece/position, guide, annotated bibliography, or review of literature. Research studies employ qualitative or quantitative designs to extract data; Theoretical works use existing literature to advance new assumptions; Descriptive works do not include, or involve, methods for gathering (anecdotal) data; Opinion pieces/positions are based on the author's perspective; Guides provide instructional advice on operations or practices; Bibliographies (annotated) provide a collated list of cited works on a topic with a brief descriptions; Review of literature will provide a review of published literature on a topic through summarization, classification, and comparison.

2.3.2. Research Design

Each research study was classified by research design (i.e. quantitative, qualitative and mixed methods research). Quantitative research uses numbers to demonstrate relationships, and qualitative research relies on language to discern relationships. The mixed methods approach involves both qualitative and quantitative approaches. Significant statements attributed to each article were collated and arranged into meaningful,

thematic units representing the evolution of my thoughts on left-handedness and brain research.

2.3.3. Participants, data sources and findings

I identified the participants in each study (e.g. students, patients, adults). I also identified the data sources used in each study (e.g. observations, timed responses, questionnaires). Lastly, I summarized the findings of each study.

2.4 Coding Procedures

Each article was coded according to publication type, research design, participants, data sources and findings.

2.4.1 Publication Types

Each article was categorized as to publication type (e.g. research study, theoretical work, descriptive work, opinion piece/position, guide, annotated bibliography, or review of literature. Research studies employ qualitative or quantitative designs to extract data; theoretical works use existing literature to advance new assumptions; descriptive works do not include, or involve, methods for gathering (anecdotal) data; opinion pieces/positions are based on the author's perspective; guides provide instructional advice on operations or practices; annotated bibliographies provided a collated list of cited works on a

topic with a brief descriptions; review of literature will provide a review of published literature on a topic through summarization, classification, and comparison.

3. Results

3.1 Publication type

My search yielded 40 publications that met my criteria. These articles are listed in Table 1. Twenty-eight of the 40 articles (70%) were identified as research articles (Angelillo, et.al., 2010; Asai, et. al., 2009; Bailey & McKeever, 2004; Beratis, 2013; Danckert, et. al., 2011; Denny, 2011; Dombrower, et. al., 1982; Faurie, et. al., 2008; Gillberg, et. al., 1984; Kates, et. al., 2006; Kelly, 2012; Kim, et.al., 2001; Larsen, et.al., 2012, Llorent,et.al., 2012; McManus, 2004; Morton & Rafto, 2006; Nicholls, et. al., 2012; Onal-Hartman, et. al., 2012; Papadatou-Pastou, et. al., 2013; Pinel & Dahaene, 2010; Ramadhani, et. al., 2006, Rodriguez & Waldenstrom, 2008; Satz, 1972; Stoyanov, et. al., 2011, Triggs, et. al., 1998; Van der Elst, et. al. (a), 2011; Van der Elst, et. al. (b), 2008; Verlager, et. al., 2011; Waldie & Hausmann, 2010). Six of the 40 articles (15%) were theoretical works (Butterworth, 1992; Corballis, 1997; Geshwind and Galaburda (a), 1985;

Geshwind & Galaburda (b), 1985; Satz, 1972; Satz & Green, 1999), three (7.5%) were opinion pieces (Costas, 1996; Kinsbourne, 1982; Robbins 1985); and three (7.5%) were reviews of literature (Flaherty, 2011; Gordon, 1986; Rippon, 2000).

Table 1

Author(s) & Year of Publication	Publication Type
Angelillo, Lucia, Trojano, and Grossi, 2010	Research Study
Asai, Sugimori, and Tanno, 2009	Research Study
Bailey & McKeever, 2004	Research Study
Beratis, 2013	Research Study
Butterworth, 1992	Theoretical Work
Corballis, 1997	Theoretical Work
Costas, 1996	Opinion Piece
Danckert, et.al., 2011	Research Study
Denny, 2011	Research Study
Dombrower, et. al., 1982	Research Study
Faurie, et.al., 2008	Research Study
Flaherty, 2011	Review of Literature
Geshwind & Galaburda (a), 1985	Theoretical Work
Geshwind & Galaburda (b), 1985	Theoretical Work
Gillberg, Waldenstrom, & Rasmussen, 1984	Research Study
Gordon , 1986	Review of Literature
Kates, et.al, 2006	Research Study
Kelly, 2012	Research Study
Kim, Yi, Ik Son, & Kim, 2001	Research Study
Kinsbourne, 1982	Opinion Piece
Larsen, Helder, & Behen, 2012	Research Study
Llorent, Satz, Brumm & Philpott, 1998	Research Study
McManus & Drury, 2004	Research Study
Morton & Rafto, 2006	Research Study

Nicholls & Shields, 2012	Research Study
Onal-Hartmann, et. al., 2012	Research Study
Papadatou-Pastou, et. al., 2013	Research Study
Pinel & Dehaene, 2010	Research Study
Ramadhani, et. al., 2006	Research Study
Rippon, 2000	Review of the Literature
Robbins, 1985	Opinion Piece
Rodriguez & Waldenstrom, 2008	Research Study
Satz, 1972	Theoretical work
Satz & Green, 1999	Theoretical Work
Stoyanov, et. al., 2011	Research Study
Triggs, 1998	Research Study
Van der Elst, et. al. (a), 2011	Research Study
Van der Elst, et. al. (b),2008	Research Study
Verlager, et.al., 2011	Research Study
Waldie & Hausmann, 2010	Research Study

3.2 Research design, participants, data sources and findings of the studies

I located 28 research studies that met my selection criteria and they are listed in Table 2. (Angelillo, et. al., 2010; Asai, et. al, 2009; Bailey & McKeever, 2004; Beratis, 2013; Danckert, et. al., 2011; Denny, 2011; Dombrower, et. al., 1982; Faurie, et.al., 2008; Gillberg, et. al., 1984; Kates, et. al., 2006; Kelly, 2012; Kim, et.al., 2001; Larsen, et. al., 2012; Llorent & Satz, 1998; McManus, 2004; Morton & Rafto, 2006; Nicholls & Shields, 2012; Onal-Hartman, et.al.,

2012; Papadatou-Pastou, et.al., 2013; Pinel & Dehaene, 2010; Ramadhani, et. al., 2006; Rodriguez & Waldenstrom, **2004?**; Stoyanov, et. al., 2011; Triggs, et. al.,1998; Van der Elst, et. al. (a), 2011; Van der Elst, et.al. (b), 2008; Verlager, et. al., 2011; Waldie & Haismann, 2010). The research design, participants, data sources, and findings of each of these studies are identified in Table 2.

Table 2

Authors	Research Design	Participants	Data Sources	Findings
Angelillo,Lucia, Trojano & Grossi, 2010	Quantitative	68-year old French male, with a history of being forced to write with right hand in childhood and a right parietal cerebral hematoma two years prior to study	Written responses to verbal dictation and instructions	Mirror writing is caused by a failure of grapho-motor functions, located in the left hemisphere, to automatically transform writing from left to right in pathological left-handedness.
Asai, Sugimori, & Tanno, 2009	Mixed methods	138 college students	Questionaires; timed motor responses	Atypical lateralization in motor and language

				functions is related to schizotypal personality traits
Bailey & McKeever, 2004	Mixed methods	2,151 college students (and their children) from Bowling Green State University and University of Toledo in NE Ohio	Questionaire and observations from 15-year longitudinal study	Increase in maternal age of mother is related to left-handedness
Beratis, 2013	Mixed methods	97 university students from the University of Athens, Greece	Questionaire and observation of performance of tasks	Left-handedness provides advantages in executive-related tasks that engage the right hemisphere
Danckert, Stottinger, Quehl & Anderson, 2011	Mixed methods	12 healthy adults; 13 adults with right- brain damage; 10 adults with left-brain damage in Helsinki, Finland	Observation of response to manual tasks	Right-brain damage cause impairment to "strategy updating" due to right insula and putamen lesions
Denny, 2011	Mixed methods	13,421 mothers (and their children)	Questionnaire	Breast-feeding (6-months +) associated with increase in right-handedness
Dombrower, Favero, King & Dombrower, 1982	Mixed methods	89 elementary students, without identifiable learning disabilities	Standard achievement test scores	Test of Left Hemisphere Ability shows strong relationship with reading and mathematics
Faurie, et.al., 2008	Mixed Methods	Study 1: 12,741 participants in	Self-administered questionnaire	Left-handedness is associated

		France; Study 2: 14,732 participants in France		with higher education and income levels
Gillberg, Waldenstrom, and Rasmussen, 1984	Mixed methods	985 third-grade students in Sweden; high functioning, without disabilities	Neurological test scores and from observations of tasks	Left-handedness shows higher risk in brain damage resulting in poorer academic performance and behavioral problems
Kates, et. al., 2006	Mixed methods	80 normal children without, and 47 with velo-caridofacial syndrome	Magnetic resonance imaging and measurement, and cognitive and behavioral assessment scores	Larger amydalas, smaller cortexes, are related to manic behavior in children
Kelly, 2012	Mixed methods	256 undergraduate students	Questionnaire	Mixed handedness is associated with schizotypy
Kim, et.al., 2001	Mixed methods	109 Korean patients with left temporal lobe epilepsy; 120 control participants	Questionnaire	Left temporal lobe epilepsy results in an increase in pathological right-handedness
Larsen, Helder, and Behen, 2012	Mixed methods	139 children raised from birth in institutions in foreign countries; their American adoptive parents	Cognitive assessment scores; parental ratings on behavior	Increased Incidence of non-right-handedness related to cognitive and behavioral deficiencies
Llorent and Satz, 1998	Quantitative	6 year –old girl with traumatic brain injury	Neurological longitudinal observations	Pathological left-handedness affects language and handedness,

		sustained at age 2.	and measurements	and plasticity and recovery is seen in younger patient, hypothetically related to assigned cells
McManus, 2004	Mixed methods	334 adults from England	Questionnaire	Laterality research is as complex as lateralized behaviors
Morton and Rafto, 2006	Mixed methods	113 students from the University of Hawaii	Questionnaires; observation of motor tasks; MRI measurements of corpus collasum	Corpus collasum size is related to deafness, but not sex
Nicholls and Shields, 2012	Mixed methods	17,1987 babies in England, Scotland and Wales	Survey, longitudinal study	Hand preference is not affected by the effects of birth stress factors
Onal-Hartman, et.al., 2012	Quantitative	30 healthy, right-handed students from University of Bochum, Germany	Observation of response time to visual stimuli	Response time to appetitive and aversive stimuli imply that emotion is not linked to a specific hemisphere
Papadatou-Pastou, et.al., 2013	Mixed methods	200 students at University of Oxford, England	Questionnaires	Demonstrates consistency in hand preference measures across questionnaire and response formats
Pinel and Dehaene, 2010	Mixed methods	209 healthy French volunteers	40 short answer questions, observable responses, and fMRI	Langauage and arithmetic are left-hemispheric, with calculation activation seen

				in specific brain structures
Ramadhani, et. al., 2006	Mixed methods	674 Dutch patients surviving bacterial meningitis	Longitudinal Study: Questionaires and Observations	Early brain damage, caused by bacterial meningitis, can cause pathological left-handedness in early childhood
Rodriguez and Waldenstrom,	Mixed methods	1,714 mothers; 1,128 children; and 1,009 kindergarten providers	Questionaires from longitudinal study	Atypical (non-right-handed) handedness seen in children with poor mental health, specifically ADHD symtoms
Stoyanov, Nikolova, and Pashalieva, 2011	Mixed methods	3,250 medical students in Bulgaria	Surveys	Seasonal levels of maternal androgen increases left-handedness in winter and summer
Triggs, 1998	Quantitative	27 year-old male with a history pathological left-handedness	Muscular response to trans-cranial magnetic stimulation	Pathological left-handedness is a marker for increased ipso-lateral function in recovery
Van der Elst, Hurks, et. al., 2011	Mixed methods	294 Dutch children and their parents	Parental questionaires and observations of children	Pregnancy/birth stress events are not important risk factors for left-handedness
Van der Elst, et.al., 2008	Mixed methods	1,856 cognitively intact adults in Holland	Questionnaire and motor tasks	No differences were found in cognitive abilities as left-handed people age

Verlager, Binkofski, Friedrich, Sedimeier, and Kompf, 2011	Quantitative	11 healthy right-handed individuals compared with individual from case study with anarchic-hand syndrome in Germany	Timed responses	Corpus callosum facilitates communication from left hemisphere, but not from right to left hemisphere
Waldie and Haismann, 2010	Mixed methods	36 elementary students reading 2 years below grade level in Aukland, New Zealand	Observation of hand response to line bisection tasks	Attention deficit hyper-active disorder (ADHD) and dyslexia share certain deficits in alertness and attention, as a dysfuntion of the right fronto-parietal network, in combination with a disturbance in hemisphere communication in the corpus callosum

3.2.1 Research design

Five out of 28 studies used a quantitative research design (17.9%), (Angelillo, et. al, 2010; Llorente &Satz, 1998; Onal-Hartmann, et al., 2012; Triggs, 1998; Verlager, et. al., 2011). Twenty-three of the studies utilized a mixed methods research design (82.1 %), (Asai, et. al., 2009; Bailey & McKeever, 2004; Beratis, 2013; Danckert, et. al., 2011; Denny, 2011;

Dombrower, et. al, 1982; Faurie, et. al., 2008; Gillberg, et. al., 1984; Kates, et. al., 2006; Kelly, 2012; Kim, et. al., 2001; Larsen, et. al., 2012; McManus, 2004; Morton & Rafto, 2006; Nicholls & Shields, 2012; Papadatou-Pastou, et. al., 2013; Pinel & Dahaene, 2010; Ramadhani, et. al., 2006; Rodriguez & Waldenstrom, 2008; Stoyanov, et. al., 2011; Van der Elst, et. al. (a), 2011; Van der Elst, et al. (b), 2008; Waldie & Hausmann, 2010). None of the studies used a qualitative research design in this meta-synthesis.

3.2.2. Participants and data sources

The studies in this meta-synthesis analyzed data collected from adults (29,986), college students (6,106), patients (883), elementary students (16,184), babies (17,198), parents (1,1714), mothers (1,714) and teachers/providers (1,009). Three involved a case study of a single individual, (one in conjunction with 11 other adults), (Angelillo & et. al., 2010; Llorent & Satz, 1998; Verlanger, et. al.,2011. Most of the participants were adults, and were involved in ten of the studies (XX%), (Angelilloo , et al., 2010; Danckert, et.al., 2011; Faurie, et. al., 2008; Kim, et. al., 2001; McManus, 2004; Papadatou, et. al., 2013; Rodriguez & Waldenstrom, YEAR; Triggs, 1998; Van der Elst, et. al., 2008; Verlager, et. al., 2011 (Nine studies involved elementary students (29 %), (Denny, 2011, Dombrower, et. al., 1982; Gillberg, et. al., 1984; Kates, et.

al., 2006; Larsen, et. al, 2012; Llorent & Satz, 1998; Rodriguez & Waldenstrom, 2008; Vander der Elst, et. al. (a), 2011; Waldie & Haismann; 2010) Four were four longitudinal studies, (Bailey & McKeever, 2004; Larsen, et al., 2012; Nicholls & Shields, 2012; Pinel and Dehaene; 2010).

Questionnaires were the most frequent source for data …

3.2.3. Findings of the Studies

The findings of the 28 research articles included in this meta-synthesis can be summarized as follows:

1. Left-handedness is a genetic trait, which allows for the steady percentage rate in the population. Left-handed motor control is under the influence of the right hemisphere of the brain, where divergent thinking and visual skills are located. The left hemisphere houses the language skills, which through the corpus callosum, assists the right brain in these areas in the case of a left-handed person. The left hemisphere is larger than right hemisphere in order to accommodate for the development of speech and language in humans. Pathological left-handedness results from brain injury to the left hemisphere. Injury to the right or left side of the brain will bring about a pathological change in hand preference. Handedness is actually considered as a

range of hand preference from completely right-handed to completely left-handed. Many people are in between.

2. Learning disorders or disabilities associated with left-handedness included ADHD, dyslexia, and hearing loss. Auditory hallucinations, behavior disorders and depression have been linked to left-handedness. In conditions of attention deprivation, orphans from birth show an increase in left-handedness. Maternal age is related to left-handedness. Breast-feeding for six months or more increases right-handedness.
3. Motivation is not associated with the right or left-brain.

3.2.3 Findings

3.3 Emergent themes

Six emergent themes emerged from my analysis of the 40 articles included in this meta-synthesis, and they include: (a) History; (b) Causes; (c) Learning Disorders and Disabilities; (d) Associated Risk Factors; (d)

Current Views of Hemispheric Dominance; (e) Future of Research. These six clusters and their formulated meanings are represented in Table 3.

Table 3

Theme Clusters	Formulated Meanings
History	● Left-handedness is represented in about 10% of the population throughout the world, and throughout history. There have been cultural biases against left-handedness. Despite the nearly universal design for the right-handed, left-handedness has persisted. Speculation about the prevalence of left-handedness among great people in our day is as pre-mature, as were the negative associations with left-handedness in the past. ● Cognitive neuroscience compares right and left hemispheres in an approach to understand the functional organization of the brain, (to better understand aphasia, apraxia, and agnosia). Of brain structures, there is special interest is the corpus callosum. ● The question has been posed: Should people be assessed for lateral preference (handedness) in order to help place individuals within certain areas of occupations? Brain lateralization and cerebral dominance is thought to give rise to distinct cognitive styles. Verbal skills are associated with the left hemisphere; visual and spatial skills are associated with the right hemisphere. Counselors should be aware of cognitive styles, and cerebral dominance in relation to schizophrenia and depression. Author recommends caution is profiling individuals like this. ● There is more than attributing control of the left hand to the right hemisphere, and the right hand to the left hemisphere in the as in the traditional split-brain theory. This corpus callosum study shows asymmetric communication from the left to the right hemisphere, through an inhibiting mechanism of action, but not from the right to the left hemisphere. ● The reduction in violence in society makes left-handedness insignificant to socio-economic status. Left-handers have higher economic status. The reproductive advantage(s), which contribute to the persistence of this polymorphism, remains to be formally investigated. ● Consider the origins of handedness: Hand dominance is observed at 8 months, grasping is observed in the first year, (however little

	is known about the acquisition of hand-to mouth coordination). Precise tool use and language are vulnerable to developmental disorders, because these are recently evolved skills, like handedness. ● Maturation of the brain, and subsequent lateralization occurs in stages, (influenced by lesions, and hormones), and results in a larger left hemisphere and asymmetry. The pathology of left-handedness is considered by 1985. ● The enlarged cortical regions are compensation, and leads to certain high talents, in left-handed people. Research suggests there is a variety, or continuum, of types of left-handedness
Causes	● Left-handedness is largely considered an inherited trait: Larger brain in humans give rise to enlarged areas of the frontal and parietal lobes, and an ability to converse, make tools and develop abstract reasoning. Handedness and brain lateralization develops according to the combinations of dominant and recessive alleles that select for efficient inter-hemispheric communication. ● Lateral preferences is established between 3 and 5 years of age. Exposure associated to birth stress does not increase left-handedness, but birth stress does affect behavior in school-aged children. ● Bacterial meningitis, resulting in brain damage, caused an increase in left-handedness, "with academic and behavioural limitations", supporting the hypothesis of "pathological left-handedness" (PLH). ● Non-right-handedness was seen in adopted children, severely deprived, with neuro-cognitive and behavior disorders. ● Maternal stress and brain pathology do not play a role in left-handedness, but results show a relationship between maternal stress and ADHD. ● Fetal exposure to androgen leading to left-handedness in children supports a seasonal pattern hypothesis. ● Maternal age is significantly associated with left-handedness. ● The longer the duration of breastfeeding increases the likelihood of right-handedness. ● Pathological Left-handedness (PLH) is a result of left-brain damage, the symptom is the left hand to assuming motor activities for the right hand. (This is not to be confused from the natural or inheritable left-handedness (NLH) ● IN PLH, there is temporary compromise in motor control, as the central nervous system reorganizes, resulting in recovery of right-hand dominance and preference, to "ipso-lateral control and mirror-writing." ● "Mirror-writing" is writing backwards, from right to left, seen after left hemisphere lesions (a stroke in the case of this study).

	● PLH is associated with a right to left manual dominance, accompanied by right cerebral dominance, resulting in non-verbal deficits. ● Pathological right-handedness (PRH) caused by epilepsy documented for the first time—supports that damage to either right or left temporal lobe leads to hypo-function of preferred hand, and a switch of hand-dominance.
Learning Disorders (or Disabilities)	● In a study not indicative of the whole spectrum of handedness, more boys than girls were left-handed, and boys scored higher than girls in executive tasks requiring higher-order functioning (orchestrating cognition, mental flexibility, inhibitory control and working memory operations). ● Right and left-brain functions in students showed the left brain having a strong relationship to reading; the right brain did not show the same relationship to reading. ● Left-handedness has associations with learning disabilities, and also with the asymmetric lateralization that lead to 3-dimensional thinking, and analysis of spatial functions that improve survival: Which leads back to the speculation that stress (maternal) can influence handedness. ● Handedness in a group of Swedish 10-year old students found left-handed boys with the highest frequency of neurological dysfunction, with poorer academic performance, and brain damage. ● In a comparison between healthy controls and children with ADHD and dyslexia, there is a better understanding of the relationship between the right hemispheric functions, and these (and other developmental disorders), in adults as well as children. ● Right and left-brain damaged patients were compared and the right brain-damaged (RBD) patients did far worse in "strategy up-dating" associated with the insula and putamen impairment from lesions
Related Risk Factors	● Mixed-handedness reflects atypical brain lateralization, and can be a marker for increased risk of ADHD associated with pre-natal exposure to maternal stress, and mental health. ● Highest creativity, motivation, is seen in bilateral activation of the hemispheres. Novelty creates an avoidance motivation and withdrawal in the right hemisphere, and this initial response is modified in the left hemisphere by approach motivation and behavior. ● Study examines preference in using the left hand for writing toward the left hand, in subtypes of atypical handedness subgroups: PLH, Mixed Handedness (MH) and Ambiguous Handedness (AH), in schizophrenia. The brain damage, alters the left hemisphere from language and contralateral control

	(handedness) functions", and is believed to have occurred in utero. ● Results show mechanism for auditory hallucinations in atypical brain lateralization. Such lateralization, spatial motor control, sematic processing might be related to schizotypical personality disorders. ● More recent study shows right-handedness correlates more with schizotypy than left-handedness. Schizophrenia is itself a complex and constellation of symptoms and behaviors.
Brain Lateralization	● Brain lateralization comes from the need to "concurrently perform different cognitive tasks with a minimum of crosstalk", and that damage to the left hemisphere can result in language skills suffering, and that the right hemisphere will compensate for a language deficit in children and adults. ● Neuro-imagining shows calculation-induced left hemispheric lateralized activation in the intra-parietal sulcus, the middle frontal gyrus, and the superior posterior parietal lobule. (Math language and arithmetic skills.) ● Appetite and aversion behaviors know no particular hemisphere, and is though to be a interaction between hemispheres.
Future Research	● Measuring hand preference is a study unto itself: This study looks at the measurement parameter consisting solely of the choice in which hand with which to write with, and the study also examines the format of tests and how left-handers approach answering bubble tests and response formats in general. ● Longitudinal studies (more than six years) needed in order to show that an age-related, cognitive decline association to left-handedness is more than small. ● The corpus callosum size and number of connections it makes bilaterally to the left and right hemispheres, is shown to relate to deafness, but not to handedness or sex? ● How little we understand about the inter-relationships between handedness and behaviors, lateralized brain functions. ● Anxiety and aggression are linked to larger amydalas, 11% and 8% larger aymdalas are found in females and males respectively with Velocardiofacial Syndrome (VCFS). The amydala provides a valence to stimuli. Synaptic density reaches a peak by age 3, and then under a process of pruning throughout puberty, which leads to brain development. Disruption to the pruning process in VCFS is linked to a gene(s) on the 22q11 region for hemizygous individuals, and this area may be related to other genes that regulate functions affecting neurodevelopment.

4. Discussion

Provided in this section is a summary of the emergent themes from the analysis of the forty articles included in this meta-synthesis. These emergent themes will become a part of my philosophy of education and educational practices.

4.1. History

Left-handedness is represented in about 10% of the population throughout the world. Despite the universal design for the right-handed, left-handedness has persisted. There is a range of possible attributes and related risks that have been associated with left-handedness. There is a lot of pseudo-science about left-handedness. However, cognitive neuroscience is starting to unravel the complicated functional organization of the brain, and its' control over left-handedness, that could lead to a better understanding of disorders, such as aphasia, apraxia and agnosia. Specific brain structures are of special interest these days, such as the corpus callosum, which connects the two lateral hemispheres of the brain. And this underlies where brain research is going these days. Science is moving away from the split-brain theory, and toward how the two halves work together.

In the past, the possibility of using lateral preference as a tool to place people in jobs and occupations: Relying on the split-brain theory, brain lateralization and cerebral dominance was thought to give rise to distinct cognitive styles that fit certain skills. Verbal skills were associated with the left hemisphere, and three-dimension visual skills associated with the right hemisphere. And, left-handedness was prematurely associated with schizophrenia and depression.

The study of left-handedness is more than a part of the split-brain theory, and more than right-brain control of the left hand. The corpus callosum is seen to facilitate communication from the left to the right hemisphere in left-handers, but not right to left. Moreover, cortical regions are enlarged in the right brain as a means of compensation for some deficits in communication. Thus we see that brains have been lateralized to a great degree in modern humans. It is thought that this degree of lateralization has evolutionarily allowed for the rise of language, and that currently we are able to multi-task in large because the brain shares duties between the different parts so well, and is wired to communicate between the two halves.

The significance of left-handedness has been studied from a socio-economic point in a current population of young professionals. Left-handers actually fair better economically, despite the fact that they have lost the need for that trait in a combative, violent, sense. Perhaps left-handers retain some element of this level of feistiness. The reproductive persistence left-handedness remains to be investigated.

Hand dominance is observed at 8 months, and grasping is observed in the first year. Handedness helps wire the brain. Because both language and developments in tool-design and manufacturing are recently evolved skills, they are particularly vulnerable to development disorders. Brain development and connectivity can be effected by the environmental. We know now that maturation of the brain, and subsequent lateralization, occurs in stages, (influenced by lesions, and hormones), and resulting in a larger left hemisphere and brain asymmetry. Today left-handedness is understood to be a place on a continuum of handedness, and that compensation of certain brain structures brain for left-hand preference can lead to certain higher talents.

4.2. Causes

Left-handedness is well established by three to five years of age, when early education begins. It is considered an inherited trait. Handedness and brain

lateralization develops according to the combinations of dominant and recessive alleles that have been selected, evolutionarily, for efficient inter-hemispheric communication. Left-handedness did not seem to increase with exposure associated to birth stress, but it was associated with bacterial meningitis, severely deprived adopted children from foreign countries, exposure to the hormone—androgen, increase in maternal age, duration of breast-feeding and pathological left-handedness (PLH) caused by lesions, or damage to the left-hemisphere.

Pathological left-handedness is a result of left-brain damage. Strokes, epilepsy, and traumatic brain injuries can cause brain damage. In these cases of PLH, the left hand of right-handed individuals temporarily assumes motor activities for the right hand. As the nervous system reorganizes, use of the right hand recovers, unusual cases of mirror-writing (writing backward, from right to left, with letter reversals) occurs, as well as non-verbal deficits, in PLH.

Pathological right-handedness (PRH) caused by epilepsy has been shown as well. This supports the idea that damage to either the right or left temporal lobe leads to hypo-function of the preferred hand and a switch of hand-dominance.

4.3. Learning Disorders and Disabilities

Left-handedness occurs in males more than females, and left-handed males score higher than left-handed females in mental functioning. Bothe left-handed males and females score high relative to right-handed counterparts. The left-hemisphere has a strong relationship to reading and the right hemisphere does not show this same relationship. Left-handedness does have associations with learning disabilities, but also special skills in three-dimensional thinking, and the analysis of spatial functions

Right-hemisphere brain functions have been related to attention deficit –hyperactive disorder (ADHD) and dyslexia. Right brain-damaged (RBD) patients do far worse in "strategy-updating " than left brain-damaged patients; the specific brain structures associated with this function are the insula and putamen. However, RBD patients do not do worse in reading. This is because the left hemisphere is helping. An old study in 1984 found a high frequency of neurological dysfunction, poor grades and "brain damage" in left-handed boys.

4.4. Associated Risk Factors

One study showed that mixed-handedness (MH) could be a marker for increased risk of ADHD associated with pre-natal exposure to maternal stress brought on by maternal mental health issues. Highest creativity and motivation is seen in bilateral activation of the left and right hemispheres:

Novelty situations creates avoidance and withdrawal in the right hemisphere, which in turn is modified by the approach motivation and behavior directives from the left hemisphere. Left-hand preference in subtypes of atypical handedness (non-right-handed) is seen in schizophrenia, and in-utero brain damage in schizophrenia alters the left hemisphere's functioning in language and contra-lateral control, or handedness. One study demonstrates the mechanism for auditory hallucinations in atypical brain lateralization (atypical or non-right-handedness), whereby the lateralization, spatial motor control and sematic processing might be related to schizotypical personality disorders (2009). Another study shows right-handedness correlates more with schizotypy than left-handedness. Schizophrenia itself is a complex disorder, which has a constellation of symptoms.

4.5. Brain Lateralization, (or hemispheric specialization)

At least as early as 1982, science has understood that brain lateralization comes from the need to "concurrently perform different tasks with a minimum of crosstalk" between hemispheres. Damage to the left hemisphere results in a loss of language skills, however the right hemisphere will compensate for this loss in children and adults.

By 2010, neuro-imaging techniques reveal that math language and arithmetic skills activate the left-hemisphere's intra-parietal sulcus, the middle frontal gyrus, and the superior posterior parietal lobule. And by 2012, science research demonstrates that appetite and aversion behaviors are aligned with no particular hemisphere, and are thought to be an interaction between the two hemispheres (and this is corroborated in another theme cluster in this meta-synthesis).

4.6. Future Research Recommendations

Hand preference has been mentioned through out this met-synthesis: Measurement of hand preference is a study in and of itself. Choice in which hand the individual chooses to write with may be the best parameter. The format of tests becomes circumspect to the process of how a left-hander approaches and answers a variety of response formats.

In order to show that left-handedness is related to age-related cognitive decline, longer longitudinal studies are needs. The size of the corpus callosum is related to deafness, but not to handedness (or sex). Little is understood about the inter-relationship between handedness, behaviors, and lateralized brain functions. But I will leave you with one last study: Anxiety and

aggression are linked to 11% larger amydalas in left-handed males, and 8% larger amydalas in left-handed females.

5.1 Conclusion

The findings in this meta-synthesis highlight the complexity of left-handedness in special education. Left-handedness is associated with some favorable genetic traits that keep it viable in our genetic make-up. There are also risks associated with left-handedness, including learning and behavior disorders. There are several causes of left-handedness, including PLH. Among the learning disorders disabilities that affect learning are ADHD, dyslexia, aphasia, and emotional and behavioral disorders (EBD).

Left-handedness is under control of the right brain which is not associated with speech and language. The left-hemisphere issues communication through the corpus callosum to the right hemisphere. IQ is considered equal in left-handers and right-handers. The right hemisphere is associated with spatial and three-dimensional visual skills, while the left hemisphere is associated with language skills, damage to either hemisphere may result in these respective areas. An interesting longitudinal study would track children from pre-school

through high school to better understand left-handedness in special education.

References

Angelillo, V., De Lucia, N., Trojano, L. & Grossi, D. (2010). Persistent left unilateral mirror writing: A neuropsychological case study. *Brain and Language (Italy), 114(3), 157-163.*

Asai, T., Sugimori, E. & Tanno, Y. (2009). Schizotypal personality traits and atypical lateralization in motor and language functions. *Brain and Cognition 71, 26-37*

Bailey, L. & McKeever, W. (2004). A large-scale study of handedness and pregnancy/birth risk event: Implications for genetic theories of handedness. Laterality 9(2), 175-188.

Beratis, I., Rabavilas, A., Kyprianou, M., Papadimitioou, G. & Papageorgiou (2013). Investigation of the link between higher order cognitive functions and handedness. *Journal of Clinical and Experimental Neuropsychology 35(4), 393-403.*

Butterworth, G. (1992). Origins of Handedness in Human Infants. *Paper*

presented at a meeting for the Spastics Society on "What handedness can tell us about developmental disorders, RIESEP1992, 2-16.

Corballis, M. (1997). The Genetics and Evolution of Handedness. *Psychological Review 104(4), 714-727.*

Costa, E. (1996). The Left-Handed: "Their Sinister" History. *University of Texas, ERIC, 1-6.*

Danckert, J., Stottinger, E., Quehl, N. and Anderson, B. (2011). Right Hemisphere Brain Damage Impairs Strategy Updating. *Cerebral Cortex, 22(12), 2,745-2,760.*

Denny, K. (2012). Breastfeeding Predicts Handedness. *Laterality, 17(3), 361-368.*

Dombrower, J., Favero, J., King Dombrower, M. & Michael, M. (1982). The Criterion-related validity of two tests hypothesized to represent left brain and right brain function for a group of elementary school children. *Educational and Psychological Measurement, 42(3).*

Faurie, C., Bonenfant, S., Goldberg, M., Hercberg, S., Zins, M. & Raymand, M. (2008). Socio-economic status and handedness in two large cohorts of French adults. *British Journal of Psychology 99, 533-554.*

Flaherty, A. (2011). Brain Illness and Creativity: Mechanisms and Treatment

Risks. Canadian Journal of Psychiatry, 56(3), 132-143

Geshwind, N., & Galaburda, A. (1985). Cerebral Lateralization, Biological Mechanisms, Associations & Pathology: I. A Hypothesis and a Program for Research. *Archives of neurology, 42, 428-459.*

Geshwind, N. & Galaburda, A. (1985). Cerebral Lateralization, Biological Mechanisms, Associations & Pathology: II. A Hypothesis and a Program for Research. *Archives of neurology, 42, 521-552.*

Gillberg, C., Waldenstrom, E. & Rasmussen, P. (1984). Handedness in Swedish 10-year-olds: Some background and associated factors. *Journal of Child Psychology and Psychiatry, 25(3), 421-432.*

Gordon , N. (1986). Left-Handedness and Learning. *Developmental Medicine and Child Neurology, 28(5), 656-661.*

Kates, W., Miller, A., Abdulsabur, N., Antshel, K., Conchelos, J., Fremon, W. & Roisen, N. (2006). Temporal Lobe Anatomy and Psychiatric Symptoms in Velocardiofacial Syndrome (22q11.2 Deletion Syndrome). *Journal of the American Academy of Child & Adolescent Psychiatry, 45(5), 587-595.*

Kelly, M. (2012). Lateral preference and schizotypy revisited: Comparison of handedness measurement and classification methods.

L*aterality, 17, 150-168.*

Kim, H., Kim, J., Yi, S. & Son, E., (2001). Evidence for the pathological Right-Handedness Hypothesis. *Neuropsychology, 15(4), 510-515.*

Kinsbourne, M. (1982). Hemispheric specialization and the growth of human understanding. *American Psychologist 37, 411-420.*

Larsen, T., Helder, E. & Behen, M. (2012). Neurocognitive and behavioral correlates of non-right-handedness in internationally adopted children, 34, 999-1,007.

Llorent, A., Satz, P., Brumm, V. & Philpott, L. (1998). Pathological left-handedness: A case report examining the developmental course of the syndrome following head trauma. *Child Neuropsychology, 8(2), 98-109.*

McManus, I. & Drury, H. (2004). The handedness of Leonardo da Vinci: A tale of the complexities of lateralization. *Brain and Cognition, 55(2), 262-268.*

Morton, B. & Rafto, S. (2006). Corpus callosum size is linked to dichotic deafness and hemisphericity, not sex or handedness. *Brain and Cognition, 62, 1-8.*

Nicholls, M., Johnston, D. & Shields, M. (2012). Adverse birth factors predict

cognitive ability, but not hand preference. *Neuropsychology, 26(5), 578-587.*

Onal-Hartmann, C., Pauli, P., Ocklenburg, S. & Gunterkun, O. (2012). The motor side of emotions: Investigating the relationship between hemispheres, motor reactions and emotional stimuli. *Psychological Research, 76, 311-316.*

Papadatou-Pastou, M., Martin, M. & Munafo, M. (2013). Measuring hand preference: A comparison among different response formats using a select sample. *Laterality, 18, 68-107.*

Pinel, P. & Dahaena, S. (2010). Beyond hemispheric dominance: Brain Regions Underlying the Joint Lateralization of Language and Arithmetic to the left hemisphere. *Journal of Cognitive Neuroscience, 22(1), 48-66.*

Ramadhani, M., Koomen, I., Grobbee, D., Van Donselaar, C., Van Furth, M. & Uiterwaal, C. (2006). Increased occurance of left-handedness after severe childhood bacterial meningitis: Support for the pathological left-handedness hypothesis. *Neuropsychologia, 44, 2,526-2532.*

Rippon, G. (2000). Left brain, right brain: Perspectives from Cognitive

Neuroscience. *Journal of Psychophysiology, 14(1), 50-52.*

Robbins, S. (1985). Left-right brain research and its premature generalization to the counseling setting. *Journal of Counseling and Development, 64(4), 235-239.*

Rodriguez, A. & Waldenstrom, U. (2008). Fetal origins of child non-right-handedness and mental health. *Journal of Child Psychology and Psychiatry, 49(9), 967-976*

Satz , P. (1972). Pathological left-handedness: An explanatory model. Cortex, 8(2), 121-135.

Satz, P. & Green, M. (1999). Atypical handedness in schizophrenia: Some methodological and theoretical issues. *Schizophrenia Bulletin, 25(1), 63-78.*

Stoyanov, Z., Nikolova, P. & Pashalieva, I. (2011). Season of birth, Geshwind and Galaburda hypothesis, and handedness. *Laterality, 16(5), 607-619.*

Triggs , W., Tesar, D. & Young, M. (1998). Ipsilateral motor control in pathological left-handedness. *Neurocase: The Neural Basis of Cognition, 4(1), 65-69.*

Vander Elst, W., Van Boxtel, M., Van Breukelen, G. & Jolles, J. (2008). Is left-

handedness associated with a more pronounced age-related cognitive decline? *Laterality, 13(3), 234-254.*

Van der Elst, W., Hurks, P., Wassenberg, R., Meijs, C., Van Boxtel, M. & Jolles, J. (2011). On the association between lateral preferences and pregnancy/birth stress events in a non-clinical sample of school-aged children. *Journal of Clinical and Experimental Neuropsychology, 33(1), 1-8.*

Verleger, R., Binkoski, F., Friedrich, M., Sedlmeier, P. Kompf, D. (2011). Anarchic-hand syndrome: ERP reflections of lost control over the right hemisphere. *Brain and Cognition, 77, 138-150.*

Waldie, K. & Hausmann, M. (2010). Right fronto-parietal dysfunction in children with ADHD and developmental dyslexia as determined by line bisection judgements. *Neuropsychologia, 48, 3,650-3,656.*