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Semantic Integration in Adults with Nonverbal Learning Disabilities and Autism Spectrum Disorder: Influence of Word Knowledge and Gestalt Perception

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Semantic Integration in Adults with Disorders of Social Perception:

Influence of Word Knowledge and Gestalt Perception

(Thesis format: Monograph)

by

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Graduate Program in Health and Rehabilitation Sciences

A thesis submitted in partial fulfillment of the requirements for the degree of
Doctor of Philosophy in Health and Rehabilitation Sciences

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Abstract

Language in individuals with nonverbal learning disabilities (NLD) and autism spectrum disorder (ASD) has been described as semantically empty and impoverished, despite apparently average word knowledge. Here, inter-related studies explored semantic representations in adults with these disorders of social perception. Studies highlighted semantic integration, a form of gestalt perception in which new concepts are developed by connecting familiar terms in novel ways. Semantic integration was compared to vocabulary breadth, and to nonverbal gestalt perception, comparing clinical groups to each other and to adults without a diagnosis. Because weaknesses in gestalt perception have been seen in NLD and ASD, it was expected that the clinical groups would show difficulty with semantic integration compared to controls, but that vocabulary would not differ between groups.

Chapter 2 presents results from two surveys administered to investigate autism symptoms in adults with NLD, ASD, or no diagnosis. Results corroborated social perception impairments in both clinical groups, and adults with NLD had survey scores above thresholds for potential ASD. Chapter 3 found no differences between groups in breadth of vocabulary, as hypothesized. The NLD group had lower scores for tests of semantic integration and gestalt perception than controls. The ASD group, however, had equal or better scores than the other groups for semantic integration, an unexpected result potentially related to formulaic language. In Chapter 4, adults with NLD provided fewer meanings for polysemous words than controls, and scores for this measure were predicted by nonverbal perceptual reasoning. Results supported clinical observations that individuals with NLD are less likely to form links between unlike but familiar words, and suggested a specific cognitive underpinning for this difficulty.

Overall, there was little to no difference between clinical groups for either quantitative or observational data concerning vocabulary breadth, but quantitative differences were seen for underlying cognitive measures. Outcomes suggested different cognitive paths by which these adults arrive at similar destinations in regard to their linguistic strengths and weaknesses.

Keywords

Co-Authorship Statement

Portions of this dissertation, not including Chapter 4, were quoted fully or adapted in part from Stothers and Oram Cardy (2016), a co-written book chapter. The chapter was written by the Candidate (MES), and comments, edits, and minor revisions were made by her Supervisor.

Stothers, M. E., & Oram Cardy, J. (2016). Nonverbal learning disabilities and Asperger syndrome in young adults: Vocabulary, gestalts, and social perception. In B. Rissman (Ed.), *Medical and Educational Perspectives on Nonverbal Learning Disability in Young Children and Adults,* (pp. 264-315). Hershey, PA: IGI Global.

Acknowledgments

There are many people who have helped me over the years that this project took. Thanks go first to my supervisor, Janis Oram Cardy, who believed in me from the start, and continued to do so no matter what challenges arose. Thanks also to JB Orange, Lisa Archibald, Andrew Johnson, Daniel Ansari, and Taslim Moosa for guidance, helpful comments, and always for listening. Without the assistance of Steve Beaulac and Steven Lee, computer questions would have remained unanswered.

Thank you to Rachael Smyth and Elaine Kwok, for help with data collection and participant recruitment, and for their patience. Olivia, Eddie, Jessie, Udani, Heather, and many other people helped in this way, and I am grateful for hours of assistance from lab coordinators, research assistants, and work study students. Staff at the University's Student Development Centre staff also helped with participant recruitment, particularly Susan Davies and Denise Dunleavey. Thanks to many former colleagues at Services for Students with Disabilities, and in Learning Skills Services. Our discussions about what it means to help, and how to best go about that, will always be appreciated. The Autism Research Training program staff, mentors, and fellow students shared ideas, interpretations, and good food and drink.

A sincere thank you and an almond milk misto to the staff and regulars at the Locomotive Espresso for your friendship, advice, and unending encouragement.

I am indebted to the friends and family who completed some of the measures as pilot participants, most particularly my sister, Marta Louise Stothers, whose insights into social differences were invaluable. Her passion for the topic and her belief in me were also a source of inspiration. Thanks to Heather, Mark, Elyse, Erin, Christina, Kevin, and Kelley for their perceptive contributions.

This work is dedicated to the students with whom I worked for many years, who shared their frustrations and triumphs openly and willingly, who expressed their gratitude for help, and who tried to explain exactly what their experiences were like in ways that I would understand. Some of these students also participated in this research, giving of their time again. I will always be grateful to each and every participant. Thank you for your time, your company, your insights, and the effort you put into this project.

Thanks to Debra Hicks for what she taught me about endurance, and for providing motivation after her own battle ended.

In memory of my parents, Catherine Ruth (Cae) and John Bailie (Jake) Stothers. My mother gave me compassion, and my father gave me perseverance. They both gave me the love and support that I needed to complete this in their absence.

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Preface

To write or even speak English is not a science but an art. There are no reliable words.

~ George Orwell

Chapter 1

1   Introduction: Potential Connections Between Social Functioning and Semantic Integration

This dissertation examines mental representations of word meanings and their integration in adults who have nonverbal learning disabilities (NLD) and autism spectrum disorder (ASD). The rationale for this work is that neither linguistic strengths nor weaknesses are well understood in either group, especially in adults. Possible explanations for a lack of research are explored, and data is presented that both quantifies and describes word knowledge and its use in a sample of adults with these disorders. A second motivation for these studies is to explore intersections between NLD and ASD as they present in verbal, educated adults.

The first section of this introductory chapter provides brief histories of NLD and of ASD, and outlines controversies surrounding their identification and diagnosis. The Introduction also includes observations arising from my clinical experience working with adults who have these disorders, and summarizes research that points to social, cognitive, and linguistic similarities in NLD and ASD. Three studies are presented in subsequent chapters. Study 1, *Social Impairment in NLD and ASD*, compares scores for social reciprocity on two autism screening surveys in adults with NLD or ASD, and volunteers without a diagnosis of disability. The survey research is presented first, in order to demonstrate that the adults with either diagnosis in the present sample do indeed demonstrate greater social impairment than is apparent in controls. The survey results reinforce issues surrounding diagnoses, and motivate the inclusion of observations and descriptions for each of the subsequent studies.

The remainder of the research focuses on semantic integration. Study 2 examines whether or to what degree adults with NLD and ASD resemble each other in their word knowledge, and then addresses potential similarities between groups in gestalt perception and semantic integration. Experiment 1, *Vocabulary and Verbal Reasoning in NLD and ASD*, analyzes receptive and expressive vocabulary to rule out the possibility that semantic integration weaknesses might be explained by poor word knowledge. The data

support the hypothesis that word knowledge is not statistically different in NLD or ASD in comparison with control participants. The data also provide a descriptive backdrop against which to evaluate subsequent results. Experiment 2, *Visual-Spatial Ability, Gestalt Perception, and Semantic Integration*, investigates a potential contribution of nonverbal gestalt perception to semantic integration. Findings suggest that adults with NLD, in particular, demonstrate difficulty with semantic integration and reduced depth in their semantic representations. Study 3, *Depth of Semantic Representations in NLD*, addresses how well the hypothesis most commonly presented for such difficulties accounts for differences between NLD and control participants. Results support an effect of perceptual organization on semantic representations, in which weak gestalt perception is related to fewer and less rich mental representations for polysemous words.

The final chapter summarizes the results, considers interpretations, and outlines implications suggested by support for most of the hypotheses. The degree to which diagnoses of NLD and ASD are related to each other is also considered in light of the findings for each of the studies presented. Statistical differences in semantic integration but not vocabulary breadth differentiate participants with a community diagnosis of NLD from those with a diagnosis of ASD; qualitative differences distinguish participants with either of these clinical disorders from adults who do not have developmental disabilities. Observations made during data collection for linguistic and nonverbal tasks also provide little difference between adults diagnosed as having NLD and ASD, whereas quantitative differences between clinical groups appear for most but not all cognitive tasks. These outcomes suggest different cognitive, and potentially developmental, paths by which these adults arrive at similar destinations in regard to their language strengths and weaknesses.

1.1 History, Definition, and Diagnosis of NLD

The term *learning disabilities* dates to the early 1960s (Danforth, 2011; Mather & Morris 2011), when it was used by Samuel Kirk to describe disordered or delayed development of a range of academic skills in children. These skills were primarily reading, but also included mathematics, written expression and handwriting, oral expression, and spelling

(Kirk & Bateman, 1962). Johnson and Myklebust (1967) were the first to use the term *nonverbal learning disabilities* (NLD), or learning problems that occurred at the perceptual level of experience. Myklebust (1975) further described the characteristics of NLD as self-imperception, including a lack of recognition of parts of one's own body and the spatial relationships between them; social imperception and facial agnosia, or an impairment in recognizing faces; difficulties understanding visual and spatial concepts such as size, height, weight, laterality and direction; perceptual speed and motor deficits; and problems with academic and life skills such as learning to print, or to dress oneself. Thus, the emphasis of this early work on NLD was on social and perceptual deficits over academic ones.

Academic achievement in NLD is not necessarily impaired in the first years of school, a point made by Rourke (2000) in exploring reasons for a general lack of research into the disorder. Using achievement tests to assign participants to groups, Rourke and his colleagues instead foregrounded psychosocial outcomes in their studies. They explored whether a predisposition to mental illnesses was part of a larger NLD syndrome originating in lateralized, or left versus right hemisphere, cortical differences (Rourke, 1989; 1995; 2000; see also Palombo & Feigon, 1986; Palombo, 2006). A related approach investigates functional consequences of the hypothesis that neuropsychological weaknesses in NLD are similar to those seen in individuals with known right hemisphere damage (Gross-Tsur, Shalev, Manor, & Amir, 1995; Humphries, Oram Cardy, Worling, & Peets, 2004; Worling, Humphries, & Tannock, 1999). In the same tradition, the work of Cornoldi, Mammarella, and their colleagues examines visual-spatial cognition in children with NLD (e.g., Mammarella et al., 2006; Mammarella, Giofré, Ferrara, & Cornoldi, 2013; Venneri, Cornoldi & Garuti, 2003), as well as delineating inclusion and exclusion criteria for clinical and research purposes (Cornoldi, Venneri, Marconato, Molin, & Montinari, 2003; Mammarella & Cornoldi, 2014).

Finally, a separate stream of research investigates the *white matter hypothesis* (Rourke, 1989; 1995) in medical syndromes characterized by disturbances to tissue in the central nervous system that is comprised mostly of myelin. Myelin is a fatty, white substance that insulates neurons and is responsible for efficient neural communication. Because the

volume of white matter is greater in the right hemisphere than the left, damage or disruption of white matter is proposed to underpin right hemisphere-biased cognitive impairments, such as visual-spatial reasoning and emotion regulation. This hypothesis of NLD (Rourke, 1989; 1995) has generated case studies of individuals with white matter damage who demonstrate features of NLD (Bonner, Hardy, Willard, & Gururangan, 2009; McCann et al., 2008; Ris et al., 2007; Rissman, 2011; Steele et al., 2005). Research reviewed in the present work did not in general include this approach. Participants with NLD diagnoses who also had known neurological conditions such as epilepsy or a history of brain tumour were excluded from the studies here, precluding any definitive conclusions about possible right hemisphere differences based on information that would have been available for only some of the participants.

NLD has not been included in any iteration of the Diagnostic and Statistical Manual of Mental Disorders (DSM), published by the American Psychiatric Association (APA) to guide practitioners in the diagnosis of mental illnesses and developmental disorders. This exclusion has resulted in part from a mismatch between diagnostic and research definitions (Ris & Nortz, 2008). In the DSM, the symptoms of learning disabilities are academic skill weaknesses rather than cognitive processes or neuropsychological impairments that underlie them. In reading disability, or dyslexia, research concerning underlying impairments has converged with the academic weakness described by the label. This has not been the case, however, with NLD. As will be explored below, there is no single academic skill that is impaired in NLD.

One consequence of NLD's exclusion from the DSM is that it is difficult to estimate its prevalence. Some estimates place prevalence at 29% of the total population with learning disabilities, which itself may be as high as 15% of school age children (Dugbartey, 2000). A more commonly cited estimate is 5% to 10% of those who seek services or accommodation for learning disorders (Davis & Broitman, 2011). A second consequence is that research concentrates on differentiating NLD from other disorders such as dyslexia, attention-deficit/hyperactivity disorder (ADHD), mood and anxiety disorders, and forms of autism (Antshel & Khan, 2008; Davis & Broitman, 2011; Fine, Semrud-Clikeman, Bledsoe, & Musielak, 2013). This in turn limits empirical exploration of

heterogeneity in NLD. Subtyping is recommended (Mammarella et al., 2006; Ris & Nortz, 2008), and subtypes have been proposed (Davis & Broitman, 2011; Forrest, 2004; Grodzinsky, Forbes, & Holmes Bernstein, 2010; Mamen, 2007; Palombo, 2006; Semrud-Clikeman & Glass, 2008), but as yet, subtyping studies have not been undertaken.

In the fifth edition of the DSM (DSM-5, APA, 2013), disorders of reading, mathematics, and written expression have been combined in a single Specific Learning Disorder diagnosis, one of seven types of Neurodevelopmental Disorder. Specifiers, or statements that further describe features of the diagnosis, reflect the original educational classifications. For this reason, it seems unlikely that the revision will alter patterns of diagnosis. Practitioners have used clinical experience, case studies, and research findings to diagnose NLD (Fine et al., 2013; Gregg, Coleman, Davis, Lindstrom, & Hartwig, 2006; Grodzinsky et al., 2010; Mamen, 2007; Palombo, 2006; Solodow et al., 2006; Yalof, 2006), and will continue to do so. In adults, particularly, the diagnosis of learning disabilities has become increasingly controversial because of the impact of a designation on accommodation for high-stakes examinations, alterations to course and program requirements, and financial or other types of support in post-secondary education and employment (Gregg et al., 2006; Harrison & Holmes, 2012; Siegel, 1999). From this perspective, it is unfortunate that the vast majority of research in NLD has been conducted with children, a situation that has begun to change only recently (Casey, 2012). The present work concentrates on adding to the sparse clinical and empirical information concerning adults with NLD and with autism spectrum disorder (ASD), introduced next.

1.2   Asperger Syndrome and the Diagnosis of Autism Spectrum Disorder

The research reported here was motivated by apparent similarities between NLD and Asperger syndrome, warranting the following discussion of changes in diagnostic terminology. Asperger syndrome was formerly defined as a subtype of Pervasive Developmental Disorder in the fourth edition of the DSM (APA, 1994). Written in 1943 and published in 1944, Hans Asperger's thesis (1944, translated in Frith, 1991) described a developmental condition that he termed *autistic psychopathy*, or what was later called

Asperger syndrome Almost contemporaneously, Kanner published eleven case studies of an emotional disorder that he called *early infantile autism* (Hippler & Klicpera, 2003). The disorders they described were notably similar, characterized by social isolation; repetitive and obsessive behaviours; inflexibility; intolerance of change; egocentricity; lack of empathy; impaired ability to communicate nonverbally; hypersensitivity to sound, touch, and other sensations; and the observation that these features occurred more frequently in males than in females (Wing, 1981). Both accounts commented on language differences, in particular the lack of social communication inherent in their patients' speech, but with dissimilar emphasis. Although both noted echolalia and pronoun reversals, Asperger's cases featured children with sophisticated or professor-like volubility and monologic and pedantic speech, who were described as "articulate yet strangely ineloquent" (Frith, 1991, p. 12). The children Kanner described more frequently had outright mutism, very limited vocabularies, or produced utterances that appeared to be nonsense or at least unrelated to the context (Frith, 1991; Wing, 1981). This difference led to the acquisition of language and its use before 36 months as being the criterion that separated autism from Asperger syndrome when these disorders were included in the DSM IV (Bennett et al., 2008).

Frith (2004) credits Wing (1981) with introducing Asperger's work to the English-speaking research community by publishing a series of cases of children and young adults who were seen in her own practice, and comparing them to those described by Asperger. Wing believed that Asperger overestimated originality, creativity, and overall intellectual capability in his patients, particularly as these qualities were expressed in language. For Wing,

> careful observation over a long period of time discloses that the content of speech is impoverished and much of it is copied inappropriately from other people or books. The language used gives the impression of being learned by rote. The meanings of long and obscure words may be known, but not those of words used every day. (p.117)

The present work builds on Asperger's and Wing's observations to examine the quality, expression, and understanding of semantic representations in ASD, and in adults with NLD.

Like NLD, Asperger syndrome has gone through diagnostic and definitional changes. The disorder was not included in the fifth edition of the DSM, as the committee reviewing its status concluded that there were insufficient data in the literature to support the separation of Asperger syndrome from other Pervasive Developmental Disorders (Swedo et al., 2012). In the past, a diagnosis of autism or Asperger syndrome was based on a triad of symptoms originally proposed by Wing and Gould, including qualitative impairments in both social interaction and social communication, and the presence of restricted, repetitive behaviors, interests, and activities (Wing & Gould, 1979; Wing, Gould, & Gillberg, 2011). The distinction between autism and Asperger syndrome rested on whether, and when, language was acquired (Bennett et al., 2008; Young & Rodi, 2014). In the DSM-5, most of the Pervasive Developmental Disorders, including Asperger syndrome, have been combined in the single ASD condition. Communication impairments were removed as an independent symptom cluster from the new ASD diagnosis, with some of the cluster's criteria being merged into the two remaining domains of (a) deficits in social communication and social interaction and (b) restricted, repetitive behaviors (APA, 2013). Linguistic abilities were coded under a specifier (*With or without accompanying language impairment*) rather than considered as one of the diagnostic criteria.

As in the case of NLD, a lack of consensus concerning diagnostic terminology and symptoms complicates any attempt to estimate prevalence. The incidence of ASD in general has increased, with current estimates of approximately 1% of the population (Anagostou et al., 2014; Davidovitch et al., 2013; Fombonne, 2009; Kim et al., 2014). It is still unclear, however, whether there has been a true rise in the incidence of ASD, an increase in diagnoses as a consequence of increased awareness of the disorder, or both. Despite these nosological difficulties, there are consistent reports that ASD occurs in males more frequently than females, and that incidence is higher in families in which ASD has already been identified (Fombonne, 2009; Zwaigenbaum et al., 2007). That is, some conclusions have been reached even as debate about the ongoing use of Asperger syndrome as a label continues (Chiang, Tsai, Cheung, Brown, & Li, 2014; Swedo et al., 2012; Tsai & Ghaziuddin, 2014).

In a recent publication, researchers referred to Asperger syndrome as a type of ASD rather than a clinical diagnosis (Anagostou et al., 2014), a solution that accommodated the change in DSM terminology without losing the wealth of detail associated with the term. This practice was applied in the present research to both NLD and ASD, in which a descriptive approach focusses on cognitive and linguistic characteristics of a sample who have been diagnosed with some form of either disorder. Some of the present sample were diagnosed as having high-functioning autism or pervasive developmental disorder not otherwise specified (PDD-NOS), and others with Asperger syndrome. For this reason, and to follow current terminology, ASD was used to describe the sample. Similarly, some participants with the features of NLD described in the next section were diagnosed as having dyseidetic dyslexia, disorders of perceptual reasoning, and atypical learning disability. NLD was used, as it is the most common description of this type of learning disability (Dugbartey, 2000; Mammarella & Cornoldi, 2014). The names for the groups reflected a lumping versus splitting decision (Gillberg, 2010; Tsai & Ghaziuddin, 2014) that did not allow definitive conclusions about nosology to be drawn, but avoided categorizing participants by diagnoses that were made at different times, under differing definitions and/or guidelines, by practitioners of differing education and qualifications who practise in a variety of regions. All of these differences may affect diagnosis as much as actual variations in individuals being assessed (Hendriksen et al., 2007; Lord et al., 2012; Stein, Klin, & Miller, 2004; Yalof, 2006). The decision also necessitated the inclusion of descriptions and observations, as seen throughout.

1.3   Convergence between NLD and Asperger Syndrome

ASD and NLD share more than disagreement about how best to identify them. Clinical accounts of individuals with these disorders show overlap in characteristic features. Wing's (1998) list of markers of Asperger syndrome adapted from Asperger's original paper and Myklebust's (1975) descriptions of individuals with NLD both include socially odd behaviour and difficulty interpreting social feedback, verbose and pedantic speech, unusual intonation, good spoken grammar and large vocabularies, atypical insight, clumsiness, tactlessness, emotional immaturity, insistence on routines and adherence to rules, and "a conspicuous lack of common sense" (Wing, p. 13). There were brief

references to a potential overlap between NLD and ASD before Klin and his colleagues undertook a detailed comparison (Klin, Volkmar, Cichetti, Sparrow, & Rourke, 1995). In introducing an influential NLD study by Weintraub and Mesulam (1983), Denckla (1983) discussed the similarity of the sample to the socially disabled children in her practice, and to children with Asperger syndrome. Similarly, a footnote in the first chapter of Frith's edited book *Autism and Asperger Syndrome* (1991) that extended Wing's earlier introduction of Asperger syndrome to English-speaking researchers and clinicians, noted:

> A number of neuropsychological investigations, recently reviewed by Semrud-Clikeman and Hynd (1990), have all identified a pattern of impairments in children which is suggestive of right hemisphere involvement. These impairments prominently include social ineptness, and the group so identified may well belong to the autistic spectrum. (p.13)

The paper to which Frith referred is *Right hemispheric dysfunction in nonverbal learning disabilities: Social, academic, and adaptive functioning in adults and children*, an early review by an investigator whose research efforts are now focussed on exploring the relationships between NLD, ASD, and attention-deficit / hyperactivity disorder (ADHD). As noted, a convergence of specific features in individuals with NLD and Asperger syndrome was later documented by researchers with expertise in both disorders (Klin et al., 1995; see also Ellis & Gunter, 1999, for a review). In that effort, as in many that followed, references to the similarity of NLD and Asperger syndrome were subsumed by a debate concerning potential differences between individuals with high-functioning autism and Asperger syndrome (e.g., Barnhill, Hagiwara, Smith Myles, & Simpson, 2000; Ghaziuddin & Mountain-Kimchi, 2004; Gunter, Ghaziuddin, & Ellis, 2002). More recently, studies have directly compared NLD and high-functioning autism (Williams, Goldstein, Kojkowski, & Minshew, 2008), particularly Asperger syndrome (e.g., Ryburn, Anderson, & Wales, 2009; Semrud-Clikeman, Walkowiak, Wilkinson, & Christopher, 2010a; Semrud-Clikeman, Walkowiak, Wilkinson, & Minne, 2010b; Semrud-Clikeman, Fine, & Bledsoe, 2014).

Empirical work, case studies, and reviews have come to a range of conclusions about the relationship between Asperger syndrome and NLD. According to some, they are separate, but co-occur frequently (Klin, in Stein et al., 2004); to others, they are indistinguishable (Pennington, 2009). One study concluded that the NLD cognitive

profile as delineated by Rourke (1989) did not adequately represent the cognitive variability seen in their participants with Asperger syndrome (Nydén et al., 2010). Using a scale that quantified psychiatric symptoms, the authors reported greater consistency in social than in cognitive impairment between NLD and ASD. In contrast, other researchers (Semrud-Clikeman et al., 2010a) have used a social criterion, "lack of spontaneous seeking to share enjoyment, interests, or achievements with others" (p. 586) to differentiate children with a diagnosis of NLD from those with ASD. Other criteria to classify participants as having ASD but not NLD included circumscribed interests, insistence on sameness, and repetitive behaviours. On that basis, visual-spatial and visual-motor impairments occurred more frequently in children with NLD than in those with Asperger syndrome. A broader range of cognitive and neuropsychological measures than was used by Nydén et al., including fluid reasoning, distinguished the clinical groups as defined in this way from controls, but not from each other. Palombo (2006) has classified NLD and ASD as different disorders, reasoning that neuropsychological similarities such as those described by Semrud-Clikeman have not translated into equivalently severe social impairments.

Finally, adults with either disorder also struggle with the use of language in social settings, or *pragmatics.* The possibility that atypical use of language might be due in part to differences in underlying semantic representations, and the ways in which they are formed, has not been a topic of study. The present work investigated semantic representations as separately from pragmatics as is possible in adults with social impairments. Particular attention was paid to semantic integration because it encompassed oral language and aspects of cognition that may be atypical in both clinical groups. The setting in which hypotheses about semantic integration were formed is described first.

1.4　Clinical Background

The origins of this project lie in my clinical experience as a disabilities counsellor, working with adult university students, most of whom had been diagnosed as having learning disabilities. The number of students diagnosed as having NLD increased over

time until they accounted for almost all of my ongoing appointments; this was in spite of estimates that dyslexia, or disordered reading, makes up approximately 90% of all learning disability diagnoses (Davis & Broitman, 2011). Individuals with dyslexia have a fundamental difficulty in creating mental representations of phoneme to grapheme links (Vellutino, Fletcher, Snowling & Scanlon, 2004), or the relationship between the smallest units of sound and the ways in which they are represented in letters (Scarborough & Brady, 2002). Imprecise representations and difficulties with manipulating them in phonological working memory have been shown in behavioral and brain imaging research to underlie the outward manifestations of dyslexia, including poor word decoding, spelling errors, and slow reading (Re, Tressoldi, Cornoldi, & Lucangeli, 2011; Swanson, 2012; Temple, 2002; Vellutino et al., 2004; Welcome & Joanisse, 2014). In contrast, phonological processing and auditory working memory have been described as areas of strength in NLD. In line with their good ability to segment words into their constituent sounds, children with NLD tend to read well in the elementary grades. Relying on a facility with sounding out words in combination with good long-term memory for language, children with NLD may amass large vocabularies. They have been described as being more likely to read for pleasure at an early age, and to read books without illustrations sooner than their peers (Foss, 1991; Rourke, Del Dotto, & Rourke, 1990; Rourke & Tsatsanis, 1996). In conversation, children with NLD may express their thoughts using language more typical of adults, with unexpected insights and detail for their age (Yalof, 2006). Parents, teachers, and other adults in these children's lives may characterize them as precocious, developing high expectations for their academic success and overall adaptability (Foss, 1991; Mamen, 2007; Palombo, 2006; Ris & Nortz, 2008).

At university and college, however, academic barriers for students with NLD with whom I worked began with the frustration of finding that the linguistic strengths on which they depended in secondary school were no longer reliable. They reported difficulties understanding course readings, finding main ideas during lectures and in texts, interpreting examination questions, and following assignment instructions. Psychoeducational assessment reports indicated that their academic strengths persisted in working with verbal material, so they found their difficulties with reading comprehension frustrating and surprising. Graduate students with NLD in particular were concerned

about seeing things differently, in their words. They reported that other students and faculty members would be impressed by the originality of their contributions, but that their own perception was that they were missing points that others considered to be entirely apparent.

There was an increase over time in the number of adults who had a diagnosis of Asperger syndrome who registered with the disability services office. These students reported similar academic difficulties as did the students with NLD. They had difficulty interpreting assignment instructions, prioritizing information in seminars, and writing within page limits. Being thorough was a strategy that had supported their academic performance in the past, but that did not work well in any of these situations. Some students did not accept their instructors' feedback that being more concise would assist readers in understanding their arguments. Few of the students with Asperger syndrome with whom I worked had undergone a thorough and detailed psychoeducational assessment, so it was not possible to compare scores on cognitive and neuropsychological tests with academic achievement. The most effective reading, writing, and examination strategies for students with Asperger syndrome, however, were similar or identical to those for NLD.

1.5   Semantic Integration

Many of these students found that multiple choice format examinations were particularly difficult. Students reported that their examination marks were higher on short answer or essay format tests than for the same material assessed by multiple choice questions. Most had at least average reading speed; consistent with this, the students did not report running out of time to complete this type of examination. Instead, they struggled to understand what was being asked. We were fortunate that some professors gave us access to completed multiple choice examinations, as in this context the sources of difficulties began to appear. On review, it became apparent that students struggled particularly with novel terms consisting of two previously known words. For example, *Marxist feminism* was interpreted as Russian feminism, rather than a form of feminism that ascribes women's oppression to capitalism. *Performance art* was interpreted as

being equivalent to theatre, rather than a form of art in which the artist's body is the medium. *Material culture* was interpreted to mean a materialistic society, rather than the study of information about a culture that can be drawn from the relationship between people and the things they own. In each of these concepts, the words that constitute them already have well-understood meanings that are only partially related to the new concept to be learned.

The process of developing new concepts by connecting old terms in new ways is referred to as semantic integration, or combinatorial semantics (Braeutigam, Swithenby & Bailey, 2008; Jung-Beeman, 2005; Koester, Holle, & Gunter, 2009; Price, Bonner, Peelle, & Grossman, 2015). Combining separate semantic representations may result in a mutual emphasis of meaning, as in *snowstorm*. In other forms such as idioms, metaphors, jargon, and slang expressions, entirely new concepts emerge. Examples include *hot dog* or *rainbow*, or more pertinent to an adult sample, *speakeasy* or *robocall*. The latter examples are idioms, a form defined by opaqueness, or the fact that they cannot be interpreted by understanding their component parts. Idioms have been described as inactive metaphors, or non-literal terms that are nonetheless understood because they are over-learned and may be used without an appreciation of their origins (Kasparian, 2013, cf. Gibbs, 1992). The critical feature that idioms and metaphors share is that they may not be understood in an additive way – *air miles* does not refer to a measurement of distance in space – but instead require the formation of an entirely new mental representation, and a broadening of the old representations as they intersect with the new concept. These examples demonstrate that the opacity of the products of semantic integration may vary by degree. A club where alcohol is sold illegally cannot be drawn from *speak* or *easy*, at least in the present time; when the term was coined, it may have been more clear that one spoke quietly about and in such clubs to avoid detection. Current familiarity with mechanized and electronic technologies, however, make it possible to draw the concept of *robocall* from its root words independently of its use in context.

At the time, there was no empirical research specific to NLD to suggest that semantic integration was impaired. Nonverbal perceptual integration resulting in the formation of a

gestalt had, however, been examined in both NLD and in ASD. Gestalt perception is a relational process in which meaningful wholes are constructed from stimulus fragments, and constituent parts differ qualitatively from the larger whole (Bölte, Holtmann, Poustka, Scheurich, & Schmidt, 2007; Kimchi, 1992). Perceptual integration deficits have been documented in NLD and in developmental disorders of the right hemisphere[1] (Denckla, 1983; Gross-Tsur et al., 1995; Rourke, 1989; Semrud-Clikeman & Hynd, 1990; Weintraub & Mesulam, 1983). In ASD, Frith had proposed the weak central coherence (WCC) theory, an account of processing strengths as well as weaknesses (1989). In WCC, a universal drive for coherence, or the effort to combine a variety of perceptual stimuli in a range of contexts into meaningful wholes, has been said to be less pronounced. Individuals with ASD have been found not to extract patterns and gists without instruction, although they are able to do so with appropriate cues (Happé & Frith, 2006; Hadad & Ziv, 2014). This tendency to overlook the gestalt in favour of its parts has been contrasted with advantages in cognitive tasks such as extracting small shapes from pictures of ordinary objects or arranging blocks into patterns, or tasks that require so-called local processes (e.g., Caron, Mottron, Berthiaume, & Dawson, 2006; Mottron et al., 2006; Shah & Frith, 1983; Muth et al., 2014, for a review). Although much of the WCC research has referred to the organization of nonverbal percepts (Van der Hallen, Evers, Brewaeys, Van den Noortgate, & Wagemans, 2015, for a review), theoretical accounts of gestalt processing do not distinguish between visual and linguistic formats. Instead, the essential cognitive process in creating meaning is constructive, or integrative, regardless of the modality in which the input to be combined is encountered (Booth et al., 2002; Coulson, 2006). This view aligns well with an embodied view of cognition (Barsalou, 2008; Gibbs, 2013; Glenberg, 1997; Wilson, 2002) that will be discussed in the study of semantic depth, in Chapter 4.

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[1] Distinctions between participant groups were originally made according to the label chosen by various researchers (NLD, NVLD, right hemisphere syndrome, left hemi-syndrome (Dugbartey, 2000), but a consensus emerged that these groups are more alike than different, and that distinctions were not based in neuropsychological or other actual differences between samples (Semrud-Clikeman & Hynd, 1990).

WCC specifically includes a failure to perceive gestalts (Happé & Booth, 2008). However, in discussion its proponents often use gestalt and global interchangeably (Brosnan, Scott, Fox, & Pye, 2004; e.g., Fitch, Fein, & Eigsti, 2015; Jarrold & Russell, 1997; Jolliffe & Baron-Cohen, 1997, 2001; Van der Hallen et al., 2015). In the present work, a distinction is made between global and gestalt, following Kimchi (1992). A gestalt is a novel, emergent product of integration, where individual parts are unlike the larger whole. In contrast, a global array may be produced additively, and single parts may stand for the whole. Distinguishing between global and gestalt was inspired in part by student experiences. Students with whom I worked felt that they did not have trouble discerning patterns (cf. Mamen, 2007), and some reported that they had no difficulty switching their perspective from details to the overall message (cf. Happé & Booth, 2008). Instead, students reported that they struggled to combine linguistic information that seemed to be unrelated into a new concept or message. Without explicit interpretations of the intended meaning, they felt that their comprehension was incomplete (see Stothers & Oram Cardy, 2016, for examples).

Isolating gestalt from global here also circumvented a debate over the relationship between local and global processing. Critics of WCC have pointed out that superior local processing does not always predict impaired global processing in ASD (Mottron, Dawson, Soulières, Hubert, & Burack, 2006; Van der Hallen et al., 2015), and Happé and colleagues themselves have argued that a local versus global dichotomy is misguided. Addressing mixed findings for WCC, Happé and Booth (2008) reported a series of developmental studies in which typical children were able to recall story gists independent of the amount of local details that they could recall; that is, global and local processing were separable (see also Milne & Szczerbinski, 2009 in adults; Van der Hallen et al., 2015, for a review). The present study examined semantic integration, rather than contrasting semantic representation measures that might have been hypothesized to separate global and local cognitive processes in their construction.

The purpose of examining semantic integration was to explore a possible relation between the students' difficulties with some forms of structural language and their difficulties with gestalt perception. It seemed that the students had difficulty with one or

more of the demands that semantic integration makes, as illustrated next by metaphor comprehension. Understanding metaphors requires the merging of previously separate mental representations of word meaning. Interpreting a metaphor like *iron curtain* requires that listeners possess semantic representations that are deep enough to allow similarities between words to emerge (Norbury, 2005a). Iron is a hard, heavy, inflexible, metal. Curtains are canonically none of these things, but iron and curtains share opaqueness. Impenetrability, the key feature of the metaphor as it is used politically, emerges from this similarity. Combining opposing physical qualities into one concept provides the novelty inherent in a first encounter with the term. This activity, along with suppressing familiar but irrelevant features of either concept, is also a source of more effortful processing than retrieving two separate, well known, lexical entries (Forgács et al., 2012; Forgács, Lukács, & Pléh, 2014; Mashal, Faust, Hendler, & Jung-Beeman, 2008; Price et al., 2015).

Thus, possible sources of difficulty for adult students with NLD and ASD included differences in (a) quantity of semantic representations, or breadth of word knowledge, (b) access to word meanings, (c) richness or depth of semantic representations, (d) flexibility of mental representations, and (e) auditory working memory. The last possibility seemed unlikely. Students with NLD tended to have at least average working memory, as documented in their assessment reports. They had already put effort into learning the terms, they were able to refer to them on the page, and they were able to read them aloud if necessary, all points that argue against working memory deficits. The other options were suggestive of processing differences that were investigated here, and have not been studied systematically in adults with either of these disorders.

Some research has examined semantic integration in disorders of social functioning, although separately from questions concerning the underlying quality and flexibility of semantic representations. A group of studies investigated homograph reading in ASD (Hala, Pexman, & Glenwright, 2007; Lopez & Leekam, 2003; Snowling & Frith, 1986), where pronunciation of a word depends on the integration of its meaning with the surrounding context. Only one study of this type included adult participants. Jolliffe and Baron-Cohen (1999) compared familiar and less familiar pronunciations of words such as

tear, for which separate meanings depend on vowel pronunciation – *tear* as in *rip*, or as in *crying*. Adult participants with Asperger syndrome had difficulty choosing and integrating the semantic representation that was appropriate to the sentence context, as compared with control participants who had equivalent reading speed, verbal IQ, and verbal memory.

A set of semantic priming studies using electroencephalography (EEG) data also found semantic integration differences in adults with ASD. One of these studies (Strandburg et al., 1993), examined neural correlates of the ability to recognize idioms. The autism group appeared to be less sensitive than controls to the demand for integration, as if the idiom condition alone provided an opportunity to bypass a need for semantic integration. In the authors' interpretation, the ASD participants appeared to respond to idioms as single lexical entries, instead of separate words that needed to be combined to apprehend their meaning. A study using sentences rather than word pairs had similar findings (Ring, Sharma, Wheelwright, & Barrett, 2007), in which conditions intended to evoke an increased demand for semantic integration failed to do so in the participants with Asperger syndrome. The clinical group appeared not to distinguish between congruent and incongruent sentence endings, suggesting that they were not integrating the meanings of words in the same manner as the controls.

In a final example, Gold, Faust, and Goldstein (2010) recorded EEG responses to a metaphor identification task. Adults with and without Asperger syndrome read Literal (*cement mixer*) and Unrelated (*violin tige*r) word pairs, as well as pairs that created Conventional (*false smile*) or Novel (*fragile pride*) metaphors. The task was to choose whether the stimuli formed meaningful expressions. A more pronounced effect for the marker of semantic integration was seen for the Asperger syndrome group in comparison with the Control group for Novel as compared to Unrelated pairs; the opposite result was found for the controls. The authors interpreted the difference as indicating that participants with Asperger syndrome expended more effort to integrate the Novel pairs than they did in attempting to integrate the Unrelated pairs. The Control group responses, in contrast, were interpreted as being less effortful, on the assumption that they more easily found a metaphoric relationship between the stimuli that made up the Novel pairs.

EEG studies of semantic integration in NLD were not found. The only behavioural study of semantic integration in NLD appeared to be my Master's thesis (Stothers, 2005). As in Jolliffe and Baron-Cohen (1999), between-group differences for semantic integration were seen in the absence of a corresponding difference for expressive vocabulary. Figures of speech like *still waters* and *faint praise* had to be interpreted after a sentence or brief paragraph illustrating the use of the metaphor – for example, "A blues singer sings about love: the sky is crying." Unpublished data indicated that the Control group had significantly higher scores for the metaphor task than either participants with NLD or participants who had both visual-spatial and phonological impairments. A group with dyslexia, however, whose scores indicated phonological impairments and average or better visual-spatial skills, did not differ from controls on metaphor interpretation. The groups with visual-spatial weaknesses had significantly lower scores for a nonverbal test of gestalt perception, described in Stothers and Klein (2010). Results supported the hypothesis that nonverbal gestalt perception was more critical to forming linguistic connections between unlike concepts than was vocabulary. A similar possibility was examined here, applied to oral language rather than reading comprehension.

In summary, a clinically observed difficulty with semantic integration in adults with NLD and ASD, and its potential origins, were examined. Study 1, *Social Imperception in NLD and ASD* (Chapter 2), explored social imperception and pragmatic weaknesses in both clinical groups, as compared to adults without developmental disorders. Breadth of vocabulary was examined in the second study, *Vocabulary and Gestalt Perception: Contributions to Semantic Integration* (Chapter 3)*,* to test the null hypothesis that word knowledge does not differ in these groups in comparison with each other or with controls. In the absence of vocabulary differences, a second, linked experiment explored the possibility that difficulty with semantic integration is related to weaknesses in nonverbal gestalt perception. The possibility of more shallow and inflexible semantic representations was addressed with adults with NLD in the third study, *Depth of Semantic Representations in NLD* (Chapter 4)*.*

Chapter 2

2 Social Impairment in NLD and ASD: Quantitative but not Qualitative Differences

The first study examined social impairment, in particular disordered social perception, common to NLD and ASD (Petti, Voelker, Shore, & Hayman-Abello, 2003; Semrud-Clikeman et al., 2010b). Social imperception was identified by Myklebust (1975) as a fundamental difficulty in NLD. Myklebust used the term to mean the integration of self-knowledge with one's social context, including the behaviour of others (Johnson & Myklebust, 1967; Myklebust, 1975). Recent evidence supports this characterization in children with NLD (Semrud-Clikeman et al., 2010b), and in children with Asperger syndrome, the type of ASD most represented in the present work. The latter authors have argued that behavioural differences seen in Asperger syndrome may be understood as stemming in part from an underlying difficulty in perceiving social intentions. Social imperception in turn leads to poor social judgment and subsequent avoidance of social interactions (Semrud-Clikeman et al., 2010b). This form of social impairment, as it relates to the development of semantic representations (see Chapter 5), is the focus in the present work. Adults who have ASD themselves have described social impairments in a similar way; that is, as foremost an underlying difficulty understanding social reasoning. This difficulty was notable in a sample of adults with ASD from whose writing a set of common, residual symptoms were drawn (Chamak, Bonniau, Jaunay, & Cohen, 2008):

> social impairment, withdrawal, difficulties in grasping emotions and understanding implicit rules and social conventions, as well as problems with generalization and poor adaptation to change... [their] personal accounts illustrate the strong association between perception, sense-making, and communication, p. 274-276

Consequently, in the present work, social impairment refers to difficulty with social perception, judgment, and interactions. This approach emphasizes both the appearance of social impairment in adults without language impairment and with good intellectual ability, as well as the overlap between ASD and NLD.

Returning to the link between social perception and communication, one of the defining characteristics of ASD is an early and persistent deficit in social communication,

generally defined in the same way as is *pragmatics*, or the "appropriate social use of language" (Volden & Phillips, 2010, p. 204). The most recent version of the DSM also describes social communication as the use of verbal and non-verbal forms of communication to maintain social reciprocity (APA, 2013).[2] Norbury (2014) has made a distinction between social communication and pragmatics, defining the former as a general term for the use of language in any social setting, and the latter as inferencing, or constructing meaning, by the integration of language with prior knowledge and experience. This last view accentuates a demand for integration and the role of structural language in pragmatics, consistent with the focus here. These definitions of social communication and pragmatics include *paralinguistics*, or nonverbal communication, and the ability to adapt language and behaviour to changes in the social environment (Paul, Miles Orlovski, Chuba Marcinko, & Volkmar, 2009). From the work of Kanner and Asperger to more recent reconceptualizations of core impairments (Chamak et al., 2008; Mandy & Skuse, 2008; Ronald & Hoekstra, 2011; Valla & Belmonte, 2013), difficulties with these abilities have been emphasized in ASD.

Each of these features has been documented in NLD as well. Shared examples have included problems with turn-taking and topic maintenance in conversations; *prosody*, or features such as pitch, speed, and rhythm of speech; adapting one's presentation style according to the audience; awareness of a listener's verbal and nonverbal responses; and eye contact, physical proximity, and other forms of nonverbal communication (Asperger, 1949, translated by Frith, 1991; Eigsti, Schuh, Mencl, Schultz, & Paul, 2012; Gross-Tsur et al., 1995; Klin et al., 1995; Landa, 2000; Paul et al., 2009; Rourke & Tsatsanis, 1996; Rutter, 1978; Ryburn et al., 2009; Semrud-Clikeman & Glass, 2008; Volden, 2004).

The extent of this list raises the question of whether common pragmatic weaknesses tell the entire story of overlap in social skill differences in NLD and ASD, or whether other

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[2] Social and communication impairments were separate domains in the definitions of autism and Asperger syndrome DSM IV (APA 1994), but these were combined in DSM-5 (APA, 2013). A new, separate diagnosis of Social (Pragmatic) Communication Disorder in the current edition equates social communication with pragmatics, essentially the ASD diagnosis without restricted and repetitive behaviours and interests (Kim et al., 2014; see p. 22 and Chapter 5).

social difficulties are involved in both disorders. In a study of children with NLD, one half to three quarters of the sample showed the flat or monotonous speech that is a typical paralinguistic difficulty in ASD (Gross-Tsur et al., 1995), but these children were also described as more generally "socially inept, withdrawn, and isolated" (p. 83). In another study that compared children with ASD and NLD directly (Semrud-Clikeman et al., 2010b), there were no statistically significant differences between groups for either the Withdrawal or Social Skills subscales on a normative behaviour rating scale completed by parents. Thus, social difficulties in the NLD group extended beyond pragmatics, a finding consistent with Rourke's conclusions that children with NLD tend to experience social withdrawal, and are more likely to develop internalized psychopathologies such as depression and anxiety (Rourke, 1988; Rourke & Fuerst, 1991; Rourke & Harnadek, 1994; see also Little, 1993; Myklebust, 1975; Palombo, 2006; cf. Forrest, 2004).

Rourke conceptualized impaired social communication as a developmental consequence of primary, secondary, and tertiary neuropsychological deficits in NLD (1989; 1995). Correlational support for a connection between poor visual-spatial reasoning and the interpretation of social cues has been seen in children, but a causal link has not been established (Galway & Metsala, 2011). Investigations of social cognition in children with NLD (Hendrikson et al., 2007; Petti, Voelker, Shore, & Hayman-Abello, 2003; see Little, 1993, for a review of earlier research) have not been carried out in adults. Case studies (Gregg & Jackson, 1989; Palombo, 1993; Wren & Eichorn, 2000), have suggested that adults with NLD continue to experience fundamental misunderstandings in their social interactions, but potential sources of miscommunication have not been investigated. It is also unknown how severe these difficulties might be, as compared with adults on the autism spectrum, or with adults who do not have learning disabilities. Notably, Johnson and Myklebust (1967) elaborated on their discussion of social imperception by contrasting the behaviour of children with NLD with that of children with autism:

> The problem of social imperception referred to here should not be confused with severely abnormal behaviour as seen in autistic children... the child who has a learning disability and who is deficient in social perception is not bizarre and makes every effort to conform ... When he happens to understand a social situation adequately, he shows elation and enthusiasm. (p. 295)

Consistent with a differentiation of odd from severely abnormal or bizarre behaviour, one approach to separating NLD and ASD drawn from clinical experience (Semrud-Clikeman, 2007) has been to use the absence (NLD) or presence (ASD) of restricted interests, repetitive and stereotyped behaviours, and sensory sensitivities (Semrud-Clikeman et al., 2010a, 2010b; Semrud-Clikeman & Glass, 2008). There has been debate about how and even whether these features of ASD are related to social communication impairments (Happé & Ronald, 2008; Mandy & Skuse, 2008; Valla & Belmonte, 2013), or whether they are separable aspects of the disorder that coincide in some but not all individuals. The debate has been complicated by the fact that ASD cannot be diagnosed without the presence of both sets of features (Posserud, Breivik, Gillberg, & Lundervold, 2013), simply expressed as a divide between social and non-social symptoms (Happé & Ronald, 2008; Valla & Belmonte, 2013). As well, non-social symptoms have been documented in other developmental disabilities, including intellectual disabilities; psychiatric conditions such as obsessive compulsive disorder, anorexia, and anxiety (Amaral, Mills Schumann, & Wu Nordahl, 2008; APA, 2013; Dawson, 2008; Leekam, Prior, & Uljarevic, 2011; Wing & Gould, 1979; Zucker et al., 2007); in ADHD (Ritvo et al., 2010; Semrud-Clikeman et al., 2010a, 2010b); and in children with visual impairments (Malloy & Rowe, 2011).

The separation of social and non-social ASD symptoms, described as *fractionation* (e.g., Brunsdon & Happé, 2014), has been seen in survey research with large samples of the general population. A survey of 7 to 9 year old twins, of whom approximately 2.5% were known to have ASD (Ronald et al., 2006a; Ronald, Happé, Price, Baron-Cohen, & Plomin, 2006b), found that Wing and Gould's original triad of impairments were divisible genetically and phenotypically within individuals, with environmental influences reduced to the degree provided by twin studies. Social behaviour, separate from communication, was least correlated with rigid, repetitive behaviour; 59% of the sample who did demonstrate social impairment did so in isolation from other symptoms (Ronald et al., 2006b). Another survey study (Posserud et al., 2013) that involved the general population rather than a purely ASD sample also found a small correlation, $r =$ .29, between social and non-social characteristics. The authors argued that a larger correlation, $r = .39$, between self-reported social difficulties and ASD diagnoses

supported the existence of ASD without the presence of repetitive behaviours and restricted interests.

Reflecting findings like these, a clinical diagnosis of Social (Pragmatic) Communication Disorder, or impaired social communication without accompanying non-social symptoms, was added to the DSM-5 (APA, 2013). The introduction codified a disabling condition characterized by pragmatic impairments that is nonetheless not ASD, a conclusion presented by language researchers as a semantic-pragmatic disorder (Boucher, 1998), or pragmatic language impairment (PLI; Conti-Ramsden & Botting, 1999), for many years (Bishop & Norbury, 2002; see Volden, 2004, for relationship to NLD; Whitehouse, Watt, Line, & Bishop, 2009, for adult outcomes). According to Volden (2004), NLD may be well-described by PLI, with the same relationship between the two disorders that may exist between PLI and ASD, namely, that children with NLD have features associated with PLI, but PLI does not necessarily imply NLD. Thus, it seemed that characterizing NLD as a social disorder without the non-social symptoms seen in ASD, the approach taken by Semrud-Clikeman and colleagues (Semrud-Clikeman, 2010a; 2010b; 2014), might also separate adults with a community diagnosis of ASD from those with one of NLD in the present sample.

In summary, it is uncertain whether social skill impairments in NLD and ASD are the same, either in kind or degree. More specifically, it is not clear whether social differences in NLD are related only to difficulties with pragmatics, whether they extend further to broad social difficulties, and whether they include symptoms of ASD such as restricted interests, repetitive behaviours, and sensory sensitivities (DSM-5, 2013; Gillberg & Gillberg, 1989; Frith, 2004; Wing & Gould, 1979), that in their expression may also affect social relationships (Leekam et al., 2011, for a review).

2.1   Research Questions and Hypotheses

Two surveys designed to screen for ASD in adults, described below, were given to all participants. Both surveys focussed on social relatedness and encompassed a variety of pragmatic skills. The surveys also had items that reflected circumscribed interests,

repetitive behaviours, and sensory sensitivities. The surveys were used to answer two questions about the relationship between ASD and NLD:

1. Are social impairments in NLD similar either in kind or in degree to those in ASD?
2. Do estimates of either or both of pragmatic difficulties and circumscribed interests distinguish adults with NLD from those with ASD?

The hypotheses were that adults with NLD would have significantly higher scores than control participants for both surveys, but that these scores would not surpass thresholds indicating potential ASD. Patterns of response by subscale, specifically, Language (including pragmatics) and Circumscribed Interests (non-social symptoms of ASD), were expected to differentiate between all three groups, with the NLD group showing higher scores than the Control group and equivalent scores to the ASD group for the Language subscale, and the ASD group having higher scores than either the Control or NLD groups for Circumscribed Interests. Assignment to clinical groups was not altered according to scores obtained for either of these surveys. The purpose of survey administration was to further investigate the relationships between NLD and ASD as they were diagnosed in the current sample. There are currently no survey tools for NLD, at least in adults (cf. Cornoldi et al., 2003).

2.2   Method

2.2.1   Participants

Participants were recruited via word of mouth, and through disability services offices at a community college and a university. Local advocacy services for individuals with ASD and with learning disabilities also referred participants. A small number of potential participants was recruited using the local section of a national website that offers free classified advertisements. These procedures were approved by the University's Health Sciences Research Ethics Board. There were more participants in this preliminary study than the group that will be described fully in the next chapter, as survey scores were used as exclusion criteria for subsequent studies. The total number of participants for whom

scores for both questionnaires were gathered was 70. Friends, relatives, roommates, and other adults with a relationship to each of the participants provided data for one of the autism surveys. No details about these adults were solicited, except for the nature of their relationship to the enrolled participant.

2.2.2   Materials and Procedure

The Ritvo Autism Asperger Diagnostic Scale – Revised (RAADS-R; Ritvo et al., 2010) is an 80-item questionnaire designed to aid clinicians in diagnosing ASD. It is a self-report instrument that asks participants to consider their social experiences and autism symptoms over a lifetime. Approximately half of the items on the RAADS-R are written to address social relatedness, and the other half reflect non-social symptoms. There are 64 *positive* items that target autism symptoms and 16 *negative* items to identify typical behaviour (Ritvo et al., 2010). Items are scored on a four point Likert scale that asks for a rating of when or if an item is true of respondents' "life experiences and personality characteristics" (p.1084). Scale points are ordered chronologically: *Never true*; *True only when I was younger than 16*; *True only now*; and *True now and when I was young*. For positive items, the last option is scored as a 3 and the first option as a 0, while the opposite is true for negatively worded items. A cut-off score of 65, above which a diagnosis of ASD should be considered, is reported. Specificity and sensitivity are reported to be above 90%.

The Social Responsiveness Scale – Adult version (SRS-A) is a 65-item survey of social reciprocity and autism symptoms completed by an adult who can report on participant behaviour in the last six months. Like the RAADS-R, items are scored using a 4 point Likert scale. Options are *Not true*, *Sometimes true*, *Often true*, and *Almost always true*, with the same 0 - 3 scores for negative items and the reverse for positive items. The SRS-A is interpreted using score ranges, rather than a single cut-off threshold. Scores between 60 and 80 suggest the presence of a mild form of ASD, with scores above 80 indicating the possibility of a more severe impairment. Specificity is reported to be 98.5% when more than one respondent rates the behaviour of a participant (Constantino & Todd, 2005). The concordance rate between the SRS and the RAADS-R questionnaires is reported to be 95.9% (Ritvo et al., 2010).

Participants received surveys in advance by email or when they arrived to participate in the study. Not all participants remembered to complete the surveys in advance, and some had to be reminded after their participation. Four potential control participants and one participant who reported having ASD had to be excluded because their survey data was incomplete. Participants were encouraged to ask for clarification from whomever was conducting data collection, but in general, questions were infrequent. Two participants with ASD asked for assistance in completing the RAADS-R from familiar adults who attended the data collection appointment with them, one a parent and one a community support worker. In both instances, the other adult helped participants to remain focussed on each question, but did not offer opinions about how to respond to specific items. Participants who emailed surveys reported that they completed them independently.

2.2.3   Analyses

Surveys were scored according to the method described above, depending on whether items reflected the presence of autism symptoms or typical behaviour; lower scores indicated fewer symptoms of ASD. Individual totals for both surveys were averaged by group and means were compared with analysis of variance. Additional analyses were carried out with five of the eight subscales reported for the RAADS-R. One of four subscales drawn from the original design of the survey was used, in addition to four that emerged from a factor analysis of scores for 779 respondents (Ritvo et al., 2010). Three of the four subscales derived from factor analysis were similar in item content to the original subscales, and were given the same names – Social Relatedness, Circumscribed Interests, and Sensory Motor. An original Language subscale was replaced on factor analysis with one that better represented Social Anxiety, but was retained in the present analysis to explore whether scores in the NLD group would be related to language-related social impairments. The version of the SRS from which the adult items used in the present study was not subdivided into scales. Items that measured pragmatics and stereotypies, and were of particular interest here, were statistically indistinguishable from an overall variable the survey's authors interpreted as reflecting "appropriate reciprocal social interaction" (Constantino & Todd, 2005, p. 656; see also Constantino et al., 2004). Consequently, only the total SRS score was included in the analysis of variance.

2.3   Results

The range of scores on the RAADS-R was 50 to 183 in the ASD group, and the mean
was 125.05; means descended to 79.05 for the NLD group and 25.19 for the Control
group (Table 2-1). A similar pattern emerged for SRS-A scores, with means that ranged
from the cut-off score between mild and more severe impairment for the ASD group
(77.86), to just below the mild range for the NLD participants as a group (56.66), to
below the impairment range in the Control group (13.45). RAADS-R scores showed a
general pattern below the diagnostic threshold score of 65 for the Control group, and
above 65 for the NLD and ASD groups. In addition to the above versus below threshold,
there was a tendency for scores to be stratified by group above 65 but below 100 (NLD),
and above both 65 and 100 (ASD).

Analysis of variance revealed statistically significant differences between group means
for the total RAADS-R and SRS-A surveys, with large to very large effect sizes (Table 2-
2). Significant differences were found for the Control versus both clinical groups' mean
scores on all five subscales of the RAADS-R. The range of F statistics was 20.76 to
40.26, and the large to very large effect sizes were produced for all comparisons.
Confidence intervals around the means were generally without overlap (Table 2-2).

The overall RAADS-R score pattern, in which NLD participants as a group scored below
the ASD group and above the Control group, also emerged, with two exceptions. The
ASD and NLD groups did not differ from each other on the Language or Social Anxiety
subscales (Ritvo et al., 2010). Variances were not homogenous for either survey's
results. However, the most conservative test available in SPSS for controlling Type 1
error when score distribution is unequal, Tamhane's T2 (SPSS, 2015), did not affect the
pattern of results that would have emerged had distributions been equal.

Sensitivity for the RAADS-R in the current study was 94%, as only one participant with a
community diagnosis of ASD scored below the clinical threshold; this participant was not

Table 2-1: Descriptive statistics for surveys and individual RAADS-R subscales by group

	Group			
	Controls	NLD	ASD	Excluded
	n = 20 (9F)	n = 21 (10F)	n = 21 (6F)	n = 6 (5F)
Survey / Factor	Mean (SD)			
	Range			
	95th %ile CI (Lower, Upper)			
RAADS-R total	25.19 (13.71)	79.05 (38.71)	125.05 (35.75)	91.17 (24.66)
	0 - 52	12 – 154	50 - 183	60 - 131
	18.95, 31.43	60.94, 97.16	108.32, 141.78	65.29, 117.05
SRS-A total	13.45 (10.72)	56.66 (26.22)	77.86 (26.37)	64.50 (25.51)
	1 - 35	10 - 106	30 - 141	31 - 94
	8.43, 18.47	44.28, 68.82	65.86, 89.86	37.73, 91.27
Social Relatedness	3.85 (2.90)	11.00 (7.2)	23.6 (9.8)	15.67 (6.06)
	0 - 9	1 - 26	4 - 39	9 - 26
	2.54, 5.19	7.63, 14.37	19.01, 28.19	9.31, 22,02
Circumscribed Interests	12.10 (8.80)	36.35 (18.2)	53.10 (22.37)	35.67 (9.97)
	0 - 34	9 - 78	29 - 78	19 - 48
	7.97, 16.23	27.83, 44.87	46.21, 60.10	25.20, 46.13
Sensory Motor	6.30 (4.93)	17.05 (10.78)	30.90 (12.61)	24.33 (6.50)
	0 - 22	0 - 36	9 - 51	18 - 33
	3.72, 8.28	12.01, 22.10	25.00, 36.80	17.51, 31.16
Social Anxiety	5.15 (3.94)	16.25 (8.03)	19.01 (7.61)	16.17 (8.47)
	0 - 11	0 - 27	5 - 30	4 - 27
	3.08, 6.72	12.49, 20.01	15.54, 22.66	7.38, 25.06
Language	2.71 (1.35)	6.90 (4.18)	10.05 (4.64)	6.83 (2.64)
	0 - 5	0 - 13	3 - 17	3 - 10
	2.10, 3.33	4.94, 8.86	7.88, 12.22	4.06, 9.60

***Note*.** Data for a control participant were excluded from this analysis, as all of her responses were either *Never true* for the positively worded items or *True now and when I was younger than 16* for the negatively worded items.

Table 2-2: Analyses of variance for RAADS-R, SRS-A, and RAADS-R factor scores

Survey or Factor	Comparison	mean difference (s.e.)	95th %ile CI (lower, upper)	*d*	*p*
RAADS-R total	Control < ASD	97.03 (8.27)	75.88, 118.17	1.93	.001
F (2, 59) = 49.23	Control < NLD	52.60 (9.11)	29.15, 76.05	1.03	.001
p < .001	NLD < ASD	44.43 (11.63)	15.40, 73.45	.90	.001
SRS-A total	Control < ASD	64.41 (6.23)	48.53, 80.28	1.93	.001
F (2, 60) = 43.65	Control < NLD	43.10 (6.33)	26.90, 59.30	1.12	.001
p < .001	NLD < ASD	21.31 (8.21)	.81, 48.53	.61	.04
Social Relatedness	Control < ASD	20.06 (2.20)	14.39, 25.72	1.82	.001
F (2, 59) = 40.92	Control < NLD	7.15 (1.74)	2.71, 11.59	.65	.001
p < .001	NLD < ASD	12.91 (2.66)	6.27, 19.54	1.16	.001
Circumscribed	Control < ASD	40.71 (3.72)	31.36, 50.05	1.85	.001
Interests	Control < NLD	24.25 (4.52)	12.75, 35.75	1.10	.001
F (2, 59) = 41.61	NLD < ASD	16.46 (5.15)	3.58, 29.34	.76	.01
p < .001					
Sensory Motor	Control < ASD	23.70 (3.04)	14.95, 31.45	1.74	.001
F (2, 59) = 27.79	Control < NLD	10.75 (2.65)	4.00, 17.50	.76	.002
p < .001	NLD < ASD	12.95 (3.72)	3.67, 22.23	.98	.04
Social Anxiety	Control < ASD	13.42 (1.92)	8.57, 18.27	.1.55	.001
F (2, 59) = 22.09	Control < NLD	11.10 (2.00)	6.02, 16.18	1.23	.001
p < .001	NLD = ASD	2.32 (2.48)	.73, 3.85	.32	n.s.
Language	Control < ASD	7.25 (s1.03)	4.61, 9.88	1.54	.001
F (2, 59) = 20.31	Control < NLD	4.05 (.97)	1.54, 6.56	.87	.001
p < .001	NLD = ASD	3.20 (1.36)	.20, 6.59	.67	n.s.

***Note*.** Lower SRS-A scores = fewer ASD symptoms endorsed by respondent; lower RAADS-R scores = fewer symptoms and/or symptoms of shorter duration. Effect sizes were calculated using the pooled standard deviation of the sample, therefore effect sizes reflect simple differences between group means.

excluded from the ASD group because his score on the SRS-A was in the likely ASD range (60–80). There was a small group of potential control participants whose scores for one or both of the surveys were above threshold (Figure 2-1). Their data were included in sensitivity and specificity calculations, reported next.
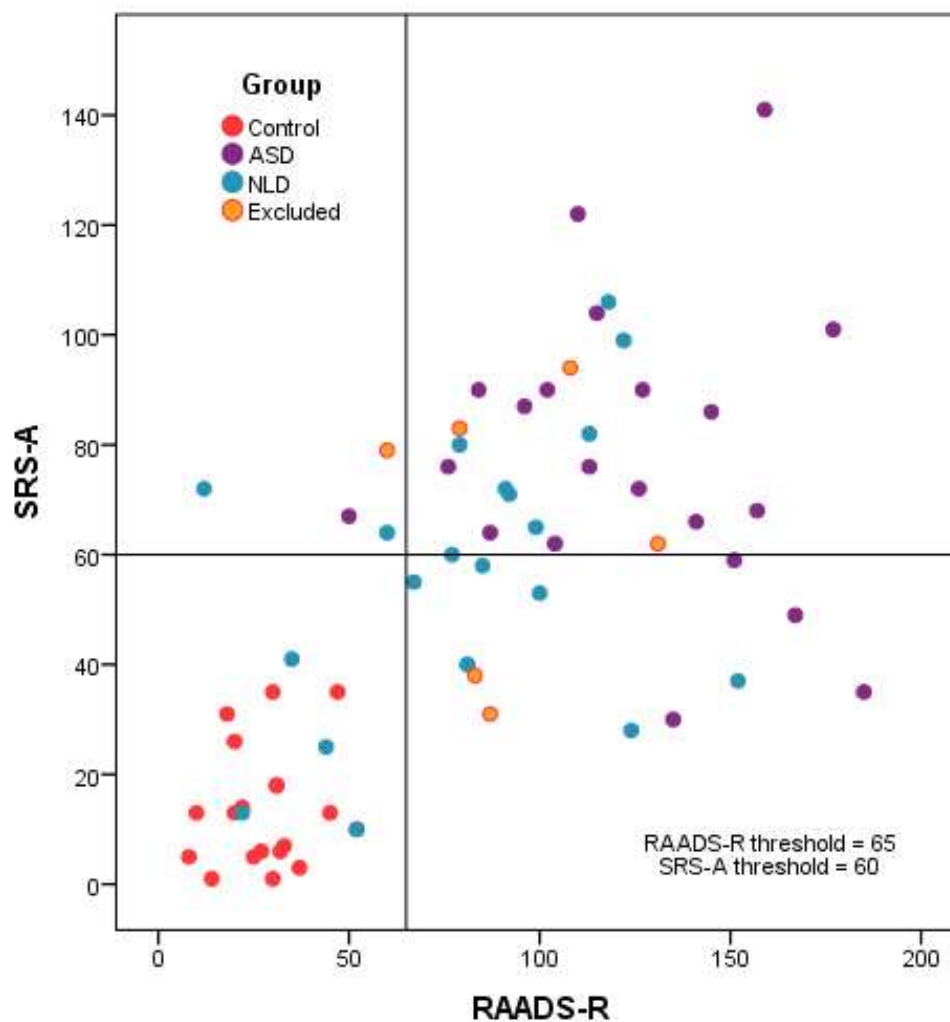
Figure 2-1. Raw scores for

RAADS-R in comparison to SRS-A for all participants

Specificity for the RAADS-R in the current study was 57%, as two-thirds of the participants in the NLD group scored above the threshold indicating possible ASD. A trend to higher scores was slightly more pronounced in the ten female participants in the NLD group, of whom seven had RAADS-R scores that were over 80. Six of 21

participants with a diagnosis of NLD had scores that were below threshold on the RAADS-R; 4 of these participants were male. Five candidates who volunteered for participation as controls were excluded from further participation due to above-threshold scores that ranged from 79 to 131. An additional potential control participant had a subthreshold RAADS-R score of 60 but an SRS-A score of 79, at the edge of the mild severity range, and bordering on the more severe range (above 80; Constantino & Todd, 2005). This individual was also excluded from any further analyses. Five of the six excluded candidates were women; four were in post-secondary programs, one had finished a college diploma, and one had completed secondary school. None reported having a diagnosis of NLD or ASD, or having undergone an assessment for a developmental disorder as a child. Two of these adults had volunteered through the online classified advertising website. The rest were recruited by word of mouth.

Sensitivity for the SRS-A in the sample, including the six participants who were later excluded, was 86%, with the behaviour of three participants who had community diagnoses of ASD being rated by parents or friends below the ASD range. Specificity was 73%, with scores for 11 of 21 participants with NLD being at or over 60. As well, there were scores of 79 and 83 for two excluded controls.

2.4   Discussion

Screening questionnaires for ASD in adults were used to test the hypothesis that adults with NLD would show social impairment. Overall, the hypothesis was supported, but to a larger degree than was anticipated. On one hand, results quantified a clinical sense that social difficulties in NLD are present but less pronounced than in adults with ASD. On the other hand, that so many of the adults with NLD scored above the RAADS-R cut-off score of 65, and/or above the lower range of impairment reported for the SRS-A, was not anticipated. Although the largest RAADS-R validation study (Ritvo et al., 2010) established a cut-off score of 65 to be optimal for calculations of sensitivity and specificity, a two-site validation study with a smaller sample (N = 272) found that a cut-off score of 72 also balanced these considerations equally (Andersen et al., 2011). The original pilot study (N = 94) produced no scores between 65 and 76 (Ritvo et al., 2008), and the authors characterized a score of 77 or more as indicating high probability of

ASD. However, even alterations to the threshold had no effect in the present study; the NLD group mean score of 79 was above all cut-off score alternatives.

With regard to the SRS-A, the mean score for the NLD group was slightly below the threshold score of 60, in comparison with a mean score of 79, above the cut-off score for the RAADS-R (Ritvo et al., 2010). This slight difference may have indicated that as a group these adults appear to be less socially different in the eyes of their peers, partners, and parents, or that they are more aware of their differences than are others. Scores ranged from 10 to 104 for the SRS-A, however, and the authors described scores from 60 to 80 that were seen for many of the present sample of adults with NLD as indicating:

> deficiencies in reciprocal social behavior that are clinically significant... which might be observed in children with the very mildest variants of pervasive developmental disorder not otherwise specified (PDD - NOS) or Asperger disorder ... [and are] associated with descriptions from peers or caregivers that the child is "odd," "socially inept," or "very nerdy. (p. 657)

Comparing social relatedness items with non-social items reflecting other symptoms of ASD was hypothesized to differentiate NLD and ASD, but this hypothesis was not supported. Two possibilities were suggested at the outset as potential explanations for high scores on the RAADS-R in the NLD group, but neither were supported on statistical analysis. First, impaired pragmatics as reflected in the Language scale might have driven the difference between the Control and NLD groups; that is, a peak for Language subscale scores might have accounted for larger than expected scores in the NLD group, without other scales having higher scores. This was not the case, as the NLD and ASD group means were not statistically different, but the effect size for a higher ASD score was moderate. Unfortunately, only three items on the RAADS-R that draw on pragmatic skills were represented on the subscale, in combination with four items that were more concerned with figurative language, e.g., *I have a hard time figuring out what some phrases mean, like "you are the apple of my eye"* (Item 7). Problems with figurative language have been documented in both NLD (Stothers & Klein, 2010) and ASD (Gold et al., 2010; Landa, 2000; Lewis, Murdoch, & Woodyatt, 2007). Thus the Language subscale was not the best test of a 'pragmatics more than other symptoms' hypothesis. An alternative method of exploring the result would be to use a scale that rates pragmatic

language separately from vocabulary and syntax (e.g. Communication Checklist – Adults; Whitehouse & Bishop, 2009).

A more likely possibility was that RAADS-R scores for the NLD group were higher than controls because impairments to social perception, judgment, and interactions, reflected in approximately half of the scale, are distinguishing features of NLD, but lower than ASD participants because non-social autism symptoms are not part of the NLD profile (Miller, in Stein et al., 2004; Semrud-Clikeman, 2007; Yalof, 2006). The RAADS-R factor that best exemplified non-social, behavioural stereotypies was the Circumscribed Interests subscale derived from factor analysis, which included restricted interests, inflexibility, repetitive mannerisms, and sensory sensitivities. However, the pattern of responses for Circumscribed Interests was not different from the total RAADS-R score pattern, or from the Social Relatedness or Sensory Motor subscales. Adults with NLD had significantly higher scores for Circumscribed Interests than control participants, ruling out the possibility that circumscribed interests and repetitive behaviours do not occur in NLD. Although these behaviours have been seen in other developmental and psychiatric conditions that were listed previously, the majority of the present NLD sample did not have the disorders in which non-social ASD symptoms have been reported. The surprising aspect of the finding was that the non-social symptoms classified broadly by clinicians and researchers alike as most reflective of autism (Forrest, 2004; Mamen, 2007; Myklebust, 1975; Palombo, 2006), even in samples that have included intellectual disabilities and other medical diagnoses, were most frequent in ASD (Matson, Demspey, & Fodstad, 2009).

As a consequence, separating NLD from ASD according to the absence of stereotyped mannerisms, interests, routines, and object manipulation (Semrud-Clikeman et al., 2010a; 2010b; 2014) was not supported, at least using the distinction as an all-or-none criterion. The NLD group did have significantly lower Circumscribed Interests scores than the ASD group, meaning that these behaviours were less frequent, less severe, or both in the group as a whole. The result pointed to the possibility that in future studies, graded cut-off scores could distinguish NLD from ASD, and from individuals without learning disabilities. Other features of NLD also suggested that a straightforward, dichotomous

division between social relatedness and all other autistic symptoms would not discriminate finely enough between NLD and ASD. Motor impairments (see chapter 3) and adherence to routines, for example, have been reported in NLD (Grodzinsky et al., 2010; Lajiness-O'Neil & Beaulieu, 2002; Palombo, 2006; Rourke, 1995; Solodow et al., 2006). Narrow interests have also been reported in NLD, with discussion about whether such interests are as all-encompassing as in ASD (Yalof, 2006).

A final point about the RAADS-R findings was that mean group scores for Social Anxiety were more similar in the two clinical groups than not, and the effect size for a higher group mean in ASD was small in comparison to the total for the RAADS-R and the other subscales. This pattern difference, in which the two clinical groups more closely resembled each other on items that reflect Social Anxiety than on Social Relatedness, could be explored in larger samples. The Communication Checklist – Adults is again a potential tool, as informant ratings are tallied for separate Pragmatics and Social Engagement subscales, in addition to the subscale that rates Language Structure (Whitehouse & Bishop, 2009).

Other potential explanations for unexpectedly high scores on both surveys in the NLD group include: (a) endorsement of a broader range of symptoms by this group of participants with NLD than has been suggested in other research, (b) insight in the participants, (c) the possibility of missed diagnoses, and (d) exclusion of participants without clinical diagnoses in other studies using the RAADS-R. Considering the first possibility, it was somewhat surprising that adults with NLD reported social impairments to the point that they scored above the potential ASD threshold. It was expected that the need to present a positive picture of oneself to others might be more pronounced for adults with learning disabilities, some of whom have reported having a history of feeling misunderstood and judged by others (Miller, in Stein et al., 2004; Palombo, 1993; Wren & Eichorn, 2000). Thus, explicitly accepting the premise that one is not normal (e.g., *I have to 'act normal' to please other people and make them like me* (Item 22) was not anticipated. Endorsements for this particular item, however, were actually slightly more frequent in the NLD group than in the ASD group. One of the 21 control participants also endorsed the item as being true. Consequently, the expectation that the NLD group

would not report a degree of social impairment that was quantitatively different from controls appeared to be an underestimate of the NLD sample's insight into their own differences.

Equally, there was no reason for the participants with NLD in the present sample to report sensory or motor impairments, detail-oriented processing, restricted interests, or stereotyped behaviours such as hand-flapping or rocking, without having experienced them. All of these autism-related symptoms were endorsed by at least some NLD participants, albeit not to the same extent as those with ASD. This type of non-social symptom was not endorsed to any degree by control participants. One possibility raised by these results was that NLD is a milder form of ASD that also includes visual-spatial deficits (cf. Forrest, 2004; Mamen, 2007; Nydén et al., 2010; Stein et al., 2004). Other possibilities are that circumscribed interests and stereotyped behaviours are not exclusive to ASD (Matson & Jang, 2014; Whitehouse et al., 2009), or that some of the adults with NLD in the present sample had undiagnosed ASD.

Regarding the latter point, true differences between groups assume that all community diagnoses in the present study were made by professionals who were familiar with both NLD and ASD, and who might have considered either differential or dual diagnoses. It is unknown whether this was the case, as diagnoses were provided by a range of practitioners, at different times in participants' lives, for a variety of presenting difficulties. Commentaries on diagnostic issues in both disorders have noted that differential diagnosis depends in part on the qualifications of the professional to whom a child or adult is referred for assessment (Hendriksen et al., 2007; Lord et al., 2012; Ris & Nortz, 2008). In addition, the history and development of ideas about each disorder have emerged from different professional traditions, and have evolved through separate streams of research. In my work experience, there were students who provided documentation of one diagnosis who also presented with signs of the other. One woman with a diagnosis of NLD also had a history of fighting and aggression as a child (Asperger, 1944/1991) and extreme social isolation. She reported selective mutism when she was in elementary school, a feature also reported by Asperger and Kanner in their initial accounts of autism (Hippler & Klicpera, 2003; Kopp & Gillberg, 1992). This

student's cognitive profile was typical of NLD, however, as were her academic struggles. Another student had been diagnosed with NLD when she entered elementary school, and continued to demonstrate below average scores for perceptual organization when she was reassessed as an adult. This student wondered if she might also have autism. She reported intense interests and delayed language acquisition. She also experienced feelings of paranoia, as have been reported in ASD (Maras & Bowler, 2012), in addition to the disorientation and discomfort in new environments described by Johnson and Myklebust (1967) in NLD. It was possible that assessing psychologists did not consider ASD in either student, as the reason for referral in both cases was difficulty with mathematics and reading comprehension. Assessment may also have been influenced by sex and gender. ASD is identified less frequently in females than in males (sex), but this may be related to differences in presentation (gender) rather than absence of ASD, at least to some degree (Giarelli et al., 2010; Kopp & Gillberg, 1992; Rivet & Matson, 2011). In order to determine whether NLD and ASD co-existed in these students, a more extensive assessment than either a purely psychoeducational or psychiatric approach provides would have been warranted.

As noted, there were six potential controls without a reported diagnosis of developmental disability who were excluded because of above-threshold scores on these surveys. Two had volunteered through the online classified advertising website, and the rest were recruited by word of mouth. Five of the six were female, potentially a reflection of the questions concerning sex and diagnosis of ASD just noted. These scores in undiagnosed adults were unexpected; specificity has been reported at 91% (Andersen et al., 2011) and 97% (Ritvo et al., 2010) for the RAADS-R. Similar estimates for the SRS have been reported, although only for children (Constantino & Todd, 2005). Validation studies for the RAADS-R did not report including participants with learning disabilities in general, however, nor participants with NLD; comparison respondents were adults with diagnosed psychiatric disorders. The SRS validation study from which the adult items were drawn also reported high specificity and the recruitment of psychiatric controls (Constantino & Todd, 2005).

A recent study (Sizoo et al., 2015) also found reduced sensitivity and specificity for the RAADS-R as it was used in a clinical setting. The goal of the study was to evaluate the survey's efficacy in screening for ASD when the possibility of other disorders was higher than in the general population, but had not yet been confirmed. In a group of 210 adults who had been referred for ASD assessment, 139 were diagnosed with ASD. Approximately one third of participants who did not have ASD nonetheless had significantly higher scores on the RAADS-R than did a control group. Seventy-one of the 210 adults had some other diagnosis, notably some that both co-occur with and may be difficult to distinguish from NLD, including ADHD, depressive disorders, and anxiety. Another subset of these participants (n = 33) had unspecified diagnoses, so it was not possible to determine whether there might have been similarities to the participants with NLD in the present sample. The conclusion was similar to the present results, in which the RAADS-R results did not clearly differentiate participants with a diagnosis of ASD from other adults, including those with a diagnosis of another disorder in combination with ASD symptoms.

The results here and in Sizoo et al. (2015) may have been related to differences between the comparison groups that were recruited, and perhaps the exclusion of outlying scores in validation research. Two studies were found that excluded candidate control participants on the basis of above-threshold RAADS-R scores (Mathersul, McDonald, & Rushby, 2013; Andersen et al., 2011). Four of a total of 37 potential control participants were excluded in the former study, but no information about them was given. In the latter article, three of eight individuals without ASD who scored above the RAADS-R threshold had psychiatric diagnoses, including ADHD. One participant formerly met criteria for ASD but no longer did at the time of the validation study (cf. Kelley et al., 2006; Suh et al., 2014). Information was not provided about the other four participants. That potential control participants were excluded in the present study by high RAADS-R scores was difficult to interpret, but evidently was not an isolated occurrence.

2.5 Implications

The question of whether survey validation studies exclude or under-report participants without diagnoses who score above threshold values was raised, suggesting that specificity and sensitivity scores are lower than has been reported (Sizoo et al., 2015). That survey validation efforts have not included participants with learning disabilities or language disorders (Bishop & Norbury, 2002), or those with NLD or other disorders of social competence, should be addressed in further validation studies. The present results suggested that an under-identification of ASD could be related to a diagnosis of NLD being preferred for females; five of six participants who had diagnoses of NLD and who also had scores of more than 80 on the RAADS-R were female. This possibility was noted as a future research question.

In the present sample, both social and non-social ASD symptoms were ratified by participants with NLD. Overall, the patterns of response recalled the nosological questions described in the Introduction. Discussion in the literature has concerned whether social and non-social symptoms are exclusive to ASD when it is considered as a syndrome, separately from psychiatric conditions that may be used for comparison purposes in research (e.g., Cervantes, Matson, Williams, & Jang, 2014). If so, the implication is that ASD is a single disorder with a range of behavioural presentations. If not, ASD may be better characterized as consisting of a set of developmental disorders that share symptoms (Matson & Jang, 2014; Gillberg, 2010; Szatmari, Bartolucci, & Bremner, 1989). The current findings would consequently add NLD to this list (see also Klin et al., 1995; Volkmar, Klin, Schultz, Rubin, & Bronin, 2000). The same discussion applies to Rourke's conception of NLD as a syndrome (1995), in which there are no fewer than fifteen medical conditions that have been described as having the essential NLD cognitive profile. These overlaps, and the findings here, contribute to uncertainty about whether the boundaries of ASD and NLD diagnoses are over- or under-inclusive (Gillberg & Fernell, 2014; Pennington, 2009), whether ASD is a form of NLD with greater social impairment (Rourke, 1995), or whether NLD is a milder form of ASD with lesser social impairment but a less variable cognitive profile (Brumback, Harper, & Weinberg, 1996; Little, 2003). Answers to these questions would have a profound

impact on the classification of NLD and ASD, as well as influence the question of whether some of the participants in the sample had either incorrect or missed diagnoses.

In the following studies, participants were assigned to NLD or ASD groups by self-report of a diagnosis by a licensed psychologist or psychiatrist, with support from a positive history of accommodation use. Community diagnoses in these participants will have varied to some degree because they were provided by more than one practitioner. It was not possible to determine whether the resulting groups were any more or less heterogeneous than samples in other research of this kind, given the ongoing discussion concerning how to operationalize definitions of both disorders in research samples (Tager-Flusberg, 2004). As a consequence, the studies here explored the boundaries of social, linguistic, and cognitive characterizations of adults with ASD and NLD diagnoses, with the goal of describing rather than definitively classifying these participants. In the next study, examples of unusual vocabulary were reported as one consequence of this approach.

Chapter 3

3   Contributing Factors to Semantic Integration: Vocabulary and Gestalt Perception

As outlined in the first chapter, semantic integration requires both breadth and depth of semantic representations (Jung-Beeman, 2005), and an ability to combine unlike parts into novel wholes, or the perception of a gestalt (Kimchi, 1992). Average or better word knowledge, shallow semantic representations, and weaknesses in *gestalt perception*, a relational process in which a meaningful whole is constructed from smaller parts, and the parts differ qualitatively from the larger whole[3], have been suggested to be commonalities in NLD and ASD (Stothers & Oram Cardy, 2012; 2016). In the article cited, we reviewed evidence that word knowledge measured with standardized tests was not different in either NLD or in Asperger syndrome from same-aged peers, and that higher-order semantic differences have been long-documented but not investigated in multiple subject research. We suggested that problems with semantics were related to generally poor integrative abilities, and that these factors contribute to shared pragmatic weaknesses in both disorders, which were indeed seen in the survey study presented in the previous chapter. Our review drew mostly on research that did not measure vocabulary or semantic depth except as in support for other hypotheses, so the two, linked studies presented in the present chapter directly explored these factors in both groups.

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[3] Gestalt perception is a form of perceptual reasoning, a set of cognitive processes used to make sense of primarily visual and spatial information with the direct assistance of language. It will be argued here that the division between visual and verbal information is not psychologically real; however, most uses of gestalt perception refer to visual-spatial reasoning. Consistent with this, perceptual reasoning is also the name for a Wechsler IQ index score, a group of subtests that measures visual working memory, mental rotation, visual-motor integration and other abilities. This IQ index was formerly called *perceptual organization*. In cognitive psychology, perceptual organization may also refer to perceptual grouping or perceptual integration, and in specific instances to gestalt perception. This will be discussed further in this chapter.

Although perceptual organization also occurs sequentially, as in phoneme discrimination during speech (Scarborough & Brady, 2002), in this paper perceptual organization and perceptual reasoning are referred to in their simultaneous, gestalt sense only (see Goldberg & Costa, 1981).

In Experiment 1, word knowledge was measured by standardized vocabulary tests to explore the hypothesis that breadth of vocabulary in ASD or NLD is not statistically different from controls. The hypothesis that there may be subtle but consistent distinctions in depth of semantic representations in both types of disorders was explored with observations. In Experiment 2, the contribution of gestalt perception to semantic integration was examined. It was hypothesized that the perception of nonverbal gestalts would be a weakness in the clinical groups as compared to control participants, and that scores for nonverbal gestalt perception and for semantic integration would be positively correlated across the sample.

3.1   Experiment 1: Vocabulary and Verbal Reasoning in NLD and ASD

The combination of verbal strengths and social skill weaknesses that is the hallmark presentation of verbal adults with ASD has also been described as being typical of NLD. In NLD, verbal IQ is by definition superior to nonverbal IQ (Mammarella & Cornoldi, 2014; Myklebust, 1975; Pelletier, Ahmad, & Rourke, 2001), and this pattern appears to be true of some individuals with ASD, particularly those who present with Asperger syndrome characteristics (Ellis & Gunter, 1999; Ghaziuddin & Gerstein, 1996; Klin et al., 1995; Fine et al., 2013 and Stothers & Oram Cardy, 2012, for reviews). Evidence is more mixed, however, when considering a broader range of the spectrum, including individuals with lower full-scale IQ scores, a diagnosis of autism, or those who have concurrent impairment in grammar, or a specific language impairment (SLI; Kjelgaard & Tager-Flusberg, 2001; Kim, Paul, Tager-Flusberg, & Lord, 2014; Lewis, Murdoch, & Woolyatt, 2007; Szatmari et al., 2009). In a follow-up of cognitive and language outcomes in adults who had a broader range of diagnoses than we surveyed, Howlin and colleagues (Howlin, Savage, Moss, Templin, & Rutter, 2014), re-tested vocabulary in a diverse sample: Mean full-scale IQ was relatively low ($M = 88$), some participants had never acquired language, some had a developmental history of language regression, and 7 had epilepsy. The authors reported approximately equal impairments for expressive and receptive vocabulary measures. However, the tests were normed up to age 16, and the mean age of the sample was 44 years. Few of the participants scored at ceiling level, but

it is unknown whether or how many typical adults over the age of 16 would reach maximum scores on these or other standardized tests.

Another adult study (Whitehouse et al., 2009) examined overlap between SLI, PLI, and autism. Case details included a 20-year-old male with ASD who had receptive and expressive language scores that were two standard deviations below his average nonverbal IQ score. This participant had originally been diagnosed as having a developmental language disorder. Although he had normal spoken language, he was reported to have impaired auditory working memory and to struggle with reading, so it was not clear whether his reduced vocabulary was related to the latter difficulties and a potential reading disability (Stothers & Klein, 2010; Vellutino et al., 2004), or to his ASD status. Rumsey and Hamburger (1988) ruled out learning disabilities in a group of ten male adults, 19 to 36 years of age, with autism. Vocabulary was average in this group, and not statistically different from a Control group. Differences were reported for a subset of language measures from an aphasia battery (Spreen & Benton, 1977, cited in Rumsey & Hamburger, 1988), including a test of verbal fluency. The authors also reported odd word choices, but noted them to be rare; examples were not provided.

Taken together, clinical anecdotes and limited research evidence suggest that adults with NLD, Asperger syndrome, and controls with approximately equal educational opportunities may not differ in semantic knowledge (Stothers & Oram Cardy, 2012), and that this conclusion may not hold when ASD groups include those with a history of language delay required for a diagnosis of autism. As well, language has not been studied extensively in adults in either clinical group, and most of the evidence collected has been incidental to the hypotheses being tested (Bartlett, Armstrong, & Roberts, 2005; Boucher, 2012; Volden, 2004). As a first step in evaluating whether semantic integration weaknesses that have been seen in other research may rest in part on limited word knowledge, the present study investigated vocabulary.

Early in their development, children with NLD and those with Asperger syndrome may excel at basic verbal skills, such as learning the alphabet and lists of new words (Eigsti, Bennetto, & Dadlani, 2007; Foss, 1991; Frith, 2004; Landa, 2000; Moss Thompson,

1985; Tsatsanis & Rourke, 2003; Thompson, 1995; Tuller, Jantzen, Olvera, Steinberg, & Kelso, 2001; Volkmar et al., 2000; Wing, 1981). As they mature, individuals with these disorders demonstrate a propensity to use language almost exclusively when they are problem solving, gathering verbal information about aspects of the world that they may not understand well, and relying heavily on their good vocabulary to negotiate the environment (Frith, 2004; Tsatsanis & Rourke, 2003). The demands of this strategy are inherently integrative, in that words are symbolic and vary in the degree to which they are connected to the objects or concepts they represent (Andrews, 2011; Oller & Rascón, 1999). Because semantic representations are internalized models of the connections between symbols and their referents (Andrews, Vigliocco, & Vinson, 2009; Gupta & Tisdale, 2009), this undertaking may be thought of as the ability to apprehend and manipulate symbolic systems. Impairments to symbolic ability are common in ASD (Noens & Berckelaer-Onnes, 2008; Paul, Chawarska, Cicchetti, & Volkmar, 2008; see Oller & Rascón, 1999, for an application of sign theory to ASD), in comparison to typical development, in which symbolic capacity emerges with the development of language (Adamson, Bakeman, & Deckner, 2003; Paul et al., 2008; Gerber, 2003). There is no NLD research that directly addresses this question, although Palombo (2006) discusses the difficulty that some, but not all, children with NLD have engaging in imaginative play and interpreting the meaning of symbolic information. As well, understanding linguistic forms such as metaphor, where one concept or object stands for another and invokes both, is a weakness in NLD (Rourke & Tsatsanis, 1996; Stothers & Klein, 2010). Thus, the characterization of people with NLD and ASD as having both verbal strengths and weaknesses in the development and apprehension of symbolic representations presents a paradox.

Clinical experience, a review (Stothers & Oram Cardy, 2012), and a small exploratory study (Stothers & Oram Cardy, 2011) all suggested a difference in depth and precision of individual semantic representations in comparison with the breadth of word knowledge. In our exploratory study, conversational samples obtained during a semi-structured interview with adults with NLD and ASD were coded for Mean Length of Utterance (MLU). The participants with AS and NLD had higher MLU scores than their typical peers for questions about strengths, weaknesses, and interests. The scores did not

distinguish the two clinical groups from each other statistically, although there was a trend for higher MLU scores for the ASD participants. That participants with clinical diagnoses produced more words to express single ideas, in combination with more irrelevant or off-topic utterances, suggested that their semantic representations could be less precise than their peers. It was also possible that the difference reflected a lack of depth, if the words they did choose could not fully express their thoughts without elaboration. In people without developmental disorders, breadth and depth of vocabulary tend to be equivalent, and depth of knowledge about a word allows easier access to it (Corrigan, 2008). The latter point would presumably make the expression of ideas more succinct in the typical group, whose mean Vocabulary score was equivalent to the means for the clinical groups.

In the following case studies in which NLD and ASD characteristics coincided, particular attention was paid to the richness as well as the precision of semantic representations in both groups. Wing (1981) described L, a 24 year-old man with a diagnosis of Asperger syndrome whose verbal IQ was higher than his performance IQ as a consequence of his large vocabulary:

> by the time he [L] went to school, he was speaking in long, involved, pedantic sentences that sounded as if they had come from books. He tended to interpret words in odd ways. For example, when hearing someone described as 'independent', he thought this meant that they always jumped in at the deep end of the pool. (p.127)

The case of Joey was presented and commented upon by clinicians with expertise in both ASD and NLD (Stein et al., 2004). Joey was a six-year-old boy who spoke intelligible words at a year, and who had advanced oral expression and reading ability at four and six years of age, respectively. Assessment showed extreme differences between Joey's verbal and nonverbal reasoning and memory scores, as is often seen in NLD (Myklebust, 1976; Mammarella & Cornoldi, 2014; Pelletier et al., 2001). Klin described Joey's use of pedantic language and his over-reliance on verbal over nonverbal means of communication as being typical of Asperger syndrome. Another report described Allen, a child in Grade 5 who was diagnosed as having NLD with ASD features (Yalof, 2006). Allen was quoted as saying "[T]he curse of my having my imagination is that there is nothing stopping me from travelling between the fragile line of reality and the realm of

fantasy" (p. 21). This sentence was included because of its concurrent eloquence and awkwardness. In this context, its subtle imprecision was also notable; people do not travel between a line and a place, but either cross a line or travel between places. The same points have been made regarding only NLD, without concomitant signs of ASD, in adults (Gregg & Jackson, 1989) and in children (Tsatsanis & Rourke, 2003). Thus, the question of whether aspects of the latter children's language, including formality, detail, and imprecision, were also present in the language of adults with NLD and ASD was examined here.

Additional work with children has suggested that in ASD, expressive language may be more well-developed than receptive language, in contrast to the pattern in typical development in which receptive language abilities surpass expressive (Mitchell, Oram Cardy, & Zwaigenbaum, 2013). For example, a study including boys with and without ASD (Kover, McDuffie, Hagerman, & Abbeduto, 2013) used the same co-normed measures of receptive and expressive vocabulary that were chosen here. The authors found lower receptive vocabulary than expressive scores for the ASD sample, and the opposite pattern in their control participants. No research in which the explicit goal was to examine an expressive better than receptive vocabulary difference in NLD, either in children or adults, was found. Case reports, however, have suggested that those with NLD may use words appropriately without necessarily having a clear representation of their meanings. Vocabulary breadth may surpass comprehension in casual conversation, at least, in which expressive mistakes are tolerated and receptive errors may be repaired (Moss Thompson, 1985; Rourke, del Dotto, Rourke, & Casey, 1990; Rourke & Tsatsanis, 1996; Thompson, 1995; see also Dobbinson, Perkins, & Boucher, 2003; Minshew, Goldstein, & Siegel, 1995; Noens & van Berckelaer-Onnes, 2005; Perkins, Dobbinson, Boucher, Bol, & Bloom, 2006; Worth & Reynolds, 2006, for examples in ASD). The question of whether receptive vocabulary scores would differ from expressive vocabulary was addressed in adults with co-normed tests of these abilities. A measure of verbal reasoning was added to examine participants' ability to manipulate semantic content in comparison with their word knowledge.

3.1.1   Research Question and Hypothesis

The present study examined the question: Are receptive vocabulary, expressive vocabulary, and verbal reasoning in adults with NLD and ASD equivalent to their peers without diagnoses? Support for the null hypothesis, that no quantitative differences for any of the tests of vocabulary or verbal reasoning would be seen between groups with ASD, NLD, or controls, was expected. In contrast, qualitative differences in depth, detail, formality, and precision, were anticipated.

3.1.2   Method

3.1.2.1   Participants

Recruitment strategies were the same as in the preliminary study described in Chapter 2. All participants were adults who had successfully completed a secondary school diploma. This inclusion criterion was used to equalize participants' educational opportunity and background as much as possible. Education was also used rather than estimates of IQ to recruit a fairly homogenous set of participants in terms of cognitive ability. Using verbal IQ in studies examining language outcomes would have introduced uninterpretable circularity to the results, and as noted, some aspects of performance IQ are lowered by definition in NLD (see Jarrold & Brock, 2004; Tager-Flusberg, 2004, for discussion in ASD).

The total sample consisted of the same 63 participants who were included in the data analysis in the previous study: 21 diagnosed with NLD (10 females), 21 diagnosed with ASD (6 females), and 21 participants without learning or other developmental disorders who made up a Control group (10 females). For inclusion in the NLD sample, participants had to have a diagnosis of NLD made by a registered psychologist, and a self-report or parent report of a history of accommodation for learning disability in elementary, secondary, or post-secondary education. Inclusion in the ASD group required a diagnosis of Asperger syndrome, high functioning Autism, or PDD-NOS, according to DSM-IV specifications (APA, 1994), and self-report or parent report of the use of community or educational supports available to people with ASD. The majority of

these participants reported a diagnosis of Asperger syndrome. Three participants reported having been diagnosed with autism, acquiring single words after three to four and a half years of age. This group was labelled ASD rather than an Asperger syndrome group to include all participants, and to be consistent with DSM-5 terminology (APA, 2013).

None of the participants had a hearing or visual impairment, and none reported a history of a brain injury, or seizure disorder. Control group volunteers had to have no history of learning or developmental problems by self-report, no use of accommodation, and demonstrate below-threshold scores on the autism screening tools described in the first study. Potential control participants were also excluded if they reported ongoing clinical depression or anxiety. The latter exclusion criteria were not applied to the other two groups. One third of the NLD sample reported a history of clinical depression. Two were taking anti-depressant medication at the time of testing, as were two participants with ASD. There were participants in both clinical samples who reported ongoing difficulties with attention. The number of participants in the two clinical samples with a secondary diagnosis of ADHD was approximately equal: three in the NLD group and two in the ASD group. At the time of testing, three participants, one in the NLD group and two in the ASD group, reported taking stimulant medication for ADHD.

The latter decisions were made in order that clinical groups would be as representative as possible of the range of co-morbidities that accompany these diagnoses. It may not be possible to fully separate psychiatric or attention disorders from either ASD (Cederlund, Hagberg, & Gillberg, 2010; Frith, 2004; Rommelse, Geurts, Franke, Buitelaar, & Hartman, 2011) or NLD (Backenson et al., 2013; Davis & Broitman, 2011; Gillberg & Bilstedt, 2000; see Matson & Cervantes, 2014 for ASD and overlapping conditions, including NLD and affective disorders; see Semrud-Clikeman et al., 2010b, for discussion of depressed mood and social withdrawal in children with ASD, NLD, and ADHD). The participants with the diagnoses of interest were already a select group in that they were well-educated. It was decided not to further idealize the sample by excluding participants with multiple diagnoses (see Howlin, 2003; Gillberg, 2010; Geurts, Sinzig, Booth, & Happé, 2014; Matson & Cervantes, 2014; for further

discussion). Additionally, it would not have been possible to recruit a large enough sample in either group if participants with ADHD symptoms or a history of depression or anxiety had been excluded.

Adults ranged in age from 19 to 44 years. Older adults were excluded to avoid aging-related changes in cognitive function, including word retrieval (Salthouse, 2004; Newman & German, 2005). Participants reported English as their first language. The majority of those in the sample were Caucasian. There was one participant of East Asian descent in each of the NLD, ASD, and Control groups, one of South Asian background in the NLD group, and one African-Canadian in both the ASD and Control groups (Table 3-1). Data concerning socioeconomic status of the participants were not collected.

Table 3-1: Participant characteristics for experiments 1 and 2

Variable	Controls	ASD	NLD
	n = 21 (10F)	n = 21 (6F)	n = 21 (10F)
Age: mean (SD)	26.46 (5.87)	27.11 (5.20)	29.24 (9.49)
Age Range	19.08 - 40.75	19.25 - 37.75	19.00 - 43.86
Education: mean (SD)	3.45 (2.30)	2.96 (2.22)	2.95 (2.02)
Education Range	.5 – 9	.5 - 6.5	.5 – 9
ADHD	n/a	2	3
Depression	n/a	3	7
Medication use	n/a	3	3

Note. Education = years of post-secondary education completed at time of testing.

3.1.2.2   Materials and Procedure

Standardized measures of vocabulary were (a) the Peabody Picture Vocabulary Test, Fourth Edition (PPVT-4, Dunn & Dunn, 2007), (b) the Expressive Vocabulary Test, Second Edition (EVT-2; Williams, 2007), and (c) the Vocabulary subtest of the Wechsler

Abbreviated Scale of Intelligence (WASI; Wechsler, 1999). The PPVT-4 is a receptive test in which participants choose one of four illustrations that best depicts a given word. In the EVT-2, participants attempt to provide a synonym for one or two words that are also presented with an illustration. For example, *What is another word for bags or luggage?* would be asked in conjunction with a drawing of a suitcase. The PPVT-4 and EVT-2 are co-normed, allowing a direct comparison of receptive and expressive vocabulary by subtracting means for the latter test from the former. The second expressive vocabulary measure, WASI Vocabulary, was used because it allows for open-ended responses rather than the single word answers that are required for the EVT-2. The Similarities subtest of the WASI was chosen to examine verbal reasoning because it is co-normed with WASI Vocabulary. In Similarities, participants are asked to explain how two objects, processes, or concepts are alike. The sample item is *How are cookies and candy alike?*, and more than one acceptable answer is listed. Data collection took place in one session, and lasted between two and three and a half hours for both experiments, depending on the speed of responses and use of rest breaks. Test format alternated between verbal and nonverbal.

3.1.2.3   Analyses

Results sections each report quantitative and observational findings. Both significance and effect size statistics are given for analyses of variance between group means, for two reasons. The primary reason is that the convention of choosing a particular statistical probability level (here, .05) to determine the significance of a result is somewhat arbitrary (Cohen, 1994). Discussions of this issue recommend including effect sizes and confidence intervals to better represent the nature of potential differences (Cohen, 1994; Ives, 2003). In published works, the inclusion of effect sizes facilitates meta-analysis, another technique for overcoming the arbitrary nature of significance testing (Nickerson, 2000).

The second reason for including effect sizes is that a power analysis indicates that to detect large effects in a three group design at 80% power, only 11 participants are necessary, but that small effects would necessitate 25 participants in each group. The

chance of finding statistically significant, moderate effects, between three groups at the p < .05 level in a sample of this size is just over 70% (Lee, 2012). Although a relatively small sample permits qualitative data to be collected by one person, power under 80% also motivates a consideration of data patterns in addition to results designated as significant. Here, effect size calculations for each measure use the pooled standard deviation of the total sample rather than the standard deviation of the Control group, as is recommended when variances for populations represented by groups are unlikely to be equal (Ives, 2003). In Lee's system (2012), effect sizes of .29, .74, and 1.15, are interpreted as small, medium, and large. The latter two values are slightly larger than Cohen's recommendations (1994) of .3, .5, and .8, and accordingly a descriptive rather than categorical approach is used. For example, an effect size of $d = .45$ is described as small to moderate.

Analyses of variance were completed on scaled scores where they were available, and on raw scores elsewhere. Post hoc comparisons for variables that were normally distributed were carried out using the Bonferroni procedure. This test is the most conservative method of reducing the probability of type 1 error when making multiple comparisons that is available in the statistical package used for these analyses (SPSS, 2013). Tamhane's T2 was used for analyses in which variances could not be assumed to be equal for the same reason. Although there were slight variations in mean age and years of post-secondary education by group (Table 3-1), means did not differ significantly. There were no significant differences for any of the dependent variables when they were analyzed by sex rather than diagnostic group, so these results also were not reported.

3.1.3   Results

Assumptions regarding homogeneity of variance across variables were examined. No outlying scores were found in the sample, and all skewness and kurtosis values were within plus or minus 2 (Roni, 2014). No transformations were made to the data.

A single table (Table 3-2) provides descriptive statistics for the dependent variables in both experiments, and two-tailed correlations between all variables across the sample

were reported in Table 3-3. Analysis of variance and post hoc comparison results were

separated by experiment (Table 3-4).

Table 3-2: Descriptive statistics for dependent variables in Experiments 1 and 2

Variable	Control (n=21)	ASD (n=21)	NLD (n=21)
		Mean (SD) Range	
Vocabulary	11.81 (2.09)	11.90 (3.52)	11.24 (2.61)
	7 – 16	4 – 18	7 – 17
EVT-2	115.19 (11.99)	110.19 (12.66)	108.76 (12.96)
	94 – 134	85 – 139	90 – 134
PPVT-4	113.05 (9.31)	110.19 (12.66)	107.90 (11.98)
	96 – 125	90 – 142	89 – 132
Similarities	11.95 (1.60)	11.52 (2.36)	11.48 (2.75)
	9 – 15	5 – 15	5 – 17
Remote Associates	12.19 (3.25)	12.29 (3.61)	9.00 (4.10)
	5 – 17	5 – 18	1 – 16
Object Assembly	48.58 (12.56)	29.20 (11.74)	23.88 (10.34)
	23 – 66	7 – 52	4 – 50
Gestalt Closure	10.48 (2.27)	10.25 (2.55)	9.00 (2.97)
	7 – 16	4 – 15	5 – 17
Block Design	12.10 (1.48)	11.38 (2.29)	9.38 (1.69)
	10 – 16	8 – 16	5 – 12
GP (preferred)	63.33 (8.25)	77.30 (16.32)	75.94 (11.99)
	50 – 77	53 – 120	57 – 105
GP (non-preferred)	69.90 (7.94)	84.45 (20.80)	79.56 (11.16)
	55 – 86	59 – 136	63 – 103

Note. ASD = Autism Spectrum Disorder; NLD = Nonverbal Learning Disabilities; Years of Education =
number of years of post-secondary education completed at time of testing; EVT-2 = Expressive Vocabulary

Test, second edition; PPVT-4 = Peabody Picture Vocabulary Test, fourth edition; GP = Grooved Pegboard; RAADS-R = Ritvo Autism Asperger Diagnostic Scale-Revised; SRS-A = Social Responsiveness Scale-Adult version. EVT-2 and PPVT-4 are standard scores with M = 100 and SD = 15. Vocabulary, Similarities, Gestalt Closure, and Block Design are scaled scores with M = 10 and SD = 3; GP scores are time in seconds to place all pegs. Remaining scores are raw scores.

3.1.3.1 Quantitative Results

There were no statistical differences between group means for WASI Vocabulary, F (2, 60) = .35, *n.s.*, EVT-2, F (2, 59) = 1.38, *n.s.*, or PPVT-4, F (2, 60) = 1.07, *n.s.* Effect sizes were negligible to small for the WASI Vocabulary measure, with a range of .04 to .27 (Table 3-2). Slightly larger effect sizes for the differences between clinical and Control group means emerged for the EVT-2 and PPVT-4, from .13 to .50, in a Control > ASD > NLD pattern. The latter two measures, co-normed tests of expressive and receptive vocabulary, also showed no between-test differences when the mean standardized scores for expressive vocabulary were subtracted from the receptive vocabulary test (Kover et al., 2013). There were no patterns by group in these results, F (2, 59) = .131, *n.s.*, and effect sizes were negligible. There were no differences between group means for the verbal reasoning measure, Similarities, F (2, 60) = .26, *n.s.*

Table 3-3: Correlations for dependent and predictor variables in Experiments 1 and 2

Variable	1	2	3	4	5	6	7	8	9	10
1. Voc	1	.65**	.72**	.52**	.27*	.10	.23	.32*	-.29*	-.31*
2. EVT-2		1	.63**	.58**	.46**	.13	.32*	.24	-.33*	-.36*
3. PPVT-4			1	.43**	.35**	.28*	.45**	.32**	-.33*	-.41**
4. Sim				1	.39**	.27*	.21	.25	-.51**	-.47**
5. RAPs					1	.36**	.49**	.48**	-.41**	-.42**
6. OA						1	.32*	.47**	-.34*	-.40**
7. GC							1	.32*	-.29*	-.49**
8. BD								1	-.57**	-.56**
9. GPp									1	.86**
10. GPnp										1

Note. Voc = Vocabulary; Sim = Similarities; RAPs = Remote Associate Problems; OA = Object Assembly; GC = Gestalt Closure; BD = Block Design; GPp = Grooved Pegboard preferred; GPnp = GP Non-preferred hand
*p < .05 (two-tailed test), ** p < .01 (two-tailed test)

Table 3-4: Comparisons of mean scores by group for dependent and predictor variables

Variable	Comparison	mean difference (s.e.)	95th %ile CI (lower, upper)	d
Vocabulary	Control = ASD	-.14 (.88)	-2.31, 2.03	.05
$F(2, 60) = .71$	Control = NLD	.57 (.87)	-1.57, 2.72	.21
	ASD = NLD	.71 (.88)	-1.46, 2.88	.26
EVT-2	Control = ASD	3.09 (4.00)	-6.78, 12.96	.24
$F(2, 59) = 2.60$	Control = NLD	6.43 (3.91)	-3.19, 16.05	.50
	ASD = NLD	3.34 (4.01)	-6.53, 13.21	.26
PPVT-4	Control = ASD	2.65 (3.52)	-6.21, 11.50	.23
$F(2, 60) = .35$	Control = NLD	5.14 (3.52)	-3.60, 13.88	.45
	ASD = NLD	2.50 (3.59)	-6.35, 11.34	.22
PPVT-4 -	Control = ASD	-.67 (3.30)	-8.81, 7.47	.06
EVT-2	Control = NLD	-1.29 (3.22)	-9.22, 6.65	.12
$F(2, 60) = .13$	ASD = NLD	-.62 (3.30)	-8.75, 7.52	.06
Similarities	Control = ASD	.65 (.70)	-1.08, 2.38	.29
$F(2, 60) = .39$	Control = NLD	.48 (.69)	-1.23, 2.19	.21
	ASD = NLD	-.18 (.70)	-1.91, 1.56	.08

Note. None of the comparisons are significantly different. Effect sizes were calculated using the pooled standard deviation of the sample; therefore effect sizes reflect simple differences between group means. PPVT-4 - EVT-2 = receptive minus expressive vocabulary.

3.1.3.2 Observations

Participants in both clinical groups used unconventional words to respond to test stimuli, including terms like *alleviate, antagonistic, audacious, balustrade, bleakness, brumous, catharsis, chrysalis, contraption, convulsive, demeanour, diaphragm, disciple, ecstatic, elated, electromagnetic, emphatic, ersatz, falsity, fortitude, impeccable, inordinate, intrinsic, lamentation, littoral, membrane, meme, metabolism, migration, notoriety,*

provocative, quell, regression, riparian, serrated, superlative, uvula, and *zealous* in response to WASI Vocabulary items[4].

None of these terms was used by participants without a diagnosis in their responses to the same items. Of the 21 members in each clinical group, there were 18 and 19 participants, in the NLD and ASD groups respectively, whose responses contributed to this list. One member of the Control group used *mutate*, another used *folklore,* and a third used the word *pejorative*. The proportion of participants with at least one unconventional response was 81% in the NLD group, 86% in the ASD group, and 14% in the Control group. A chi-square test found that the difference in these proportions was significant, χ^2 $(2, N = 63) = 33.07, p < .001$.

Choices about distinctiveness of the terms were made based on general unfamiliarity and on the context in which the words appeared. Lack of familiarity was judged by searching the MRC database (Coltheart, 1981) for each term. Two potential items, *hierarchy* and *obstinate*, were excluded after being rated by the search as being moderately familiar: 409 and 390 respectively, on a scale that ranges from 0 - 700. None of the other words on the list were found. Lack of conventionality was also rated in the context of full responses, which cannot be reproduced here. That is, many of these words were surrounded by fillers, formulaic expressions, and more familiar and non-specific words such as *thing* and *object*, that made the specificity of these terms more notable. The items were not classified by another rater, however, and null findings for a database search cannot rule out familiarity ratings existing elsewhere. A project designed to quantify the qualitative data reported here is underway.

Participants with a diagnosis also used less common synonyms on the EVT-2. Some of these words were not only correct but more sophisticated than the options given by the test. For example:

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[4] All examples were adapted from the original test items, and from participant responses if the responses included the test stimuli. No items have been used verbatim, in accordance with copyright and appropriate use of standardized tests.

NLD05: What is another word for energetic? Exuberant.

ASD12: What is another word for sad? Lachrymose.

Clinical impressions of overly formal language, loquaciousness, and detailed answers in children and adolescents (Frith, 1991; Ghaziuddin & Gerstein, 1996; Tsatsanis & Rourke, 2003; Wing, 1981; Yalof, 2006) were also seen in these adults. For example:

What is a mammal?

NLD11: A walking vertebrate creature.

NLD08: A creature that walks on all four legs because its skeletal structure will not permit it to walk on only two.

ASD07: A walking terrestrial species, one of the ... ah ... zoology is the study of these creatures; something with fur.

ASD01: A quadruped with fur and heavy bones that gives birth to only a few offspring at a time, and has a larger brain than non-mammals like amphibians.

Generally, participants with a clinical diagnosis used more words per item than did comparison participants, as indicated by the length of recordings made when data was collected for the Vocabulary and Similarities subtests. One WASI Vocabulary recording for a pilot participant who reported ASD was 45 minutes long. There are no time limits for Vocabulary, but according to the manual, the total battery of four tests is typically administered in 30 minutes (Wechsler, 1999). This participant defined words by explicitly including etymology, history, and antonyms wherever he could, in spite of feedback that these details were unnecessary. Another participant with ASD and one with NLD also included these details in their definition. The longest recording for a participant with NLD was 19 minutes, and was characterized by numerous instances of verbal problem-solving (cf. Gregg & Jackson, 1989) and self-monitoring. For example:

NLD04: *Accuse*: To put an accusation on something or somebody, [pause ...] they're usually harsh feelings. If you accuse somebody for something it means that you are [pause…] how to describe that [pause…] I don't know why I'm having so many troubles with that – um, how do I describe charge, to charge somebody means that it could be something that they've done wrong, or maybe something that you did wrong and you're accusing them for an event that happened. Yeah. You're charging, incriminating.

Participants with NLD and ASD had difficulty accessing words, as evidenced by fillers and attempts at articulating tip of the tongue moments:

> NLD06: It's an unpleasant characteristic ... I'm not sure; *it's on the tip of my head*, not really there.

> NLD03: I don't want to say keep track… I don't know how to say this… not take care. I can't… to make sure everything's in order. There, that's what [it] means.

> ASD03: And a pattern…pattern ... I would say would be, um, like a um, like in politics. It would be, a pa- pattern would be something that occurs again and again. And it might be in different ways but it's, it's like a theme in terms of, like, like in terms of votes, er, it's hard for me to explain …yeah, yeah, but to me it's like, it's like the same thing happening again and again… something over a long, long period of time, like in politics. That's what I think of pattern.

Repetitive responses were seen in both groups:

> NLD10: *something / something you do / somewhere you go* [for almost all definitions, without articulating an object, a place, an activity, etc.]

> ASD20: It's *the very thing / the very word* [for 5 of the first 15 definitions]

Imprecise responses were seen as well, particularly when participants elaborated or gave extra details. For example:

> NLD03: Rash is like the opposite of caution, when you're too, *when you take too long*, no wait, no no, wait a second I'm confused now. Yes. No, I don't know.

> ASD08: To be rash is to rush into something recklessly, or react quickly to a particular situation; also to *exercise caution*; to be rash; to react quickly and cautiously.

Some of the imprecise responses suggested difficulties with describing the ways in which objects function, or *affordances*, and with one exception, these errors were specific to the clinical groups.

> ASD07: *utilities* for *utensils*

> ASD02: *buzzer* described as a type of *noise* [instead of the device that makes a noise]

> ASD18: a pendulum equated with a *ball bearing*

> NLD16: a *wagon* is a means of transportation [could not give more detail]

> NLD20: a *wagon* is a *transportation method that you can put things in*

Participants with NLD in particular made errors regarding time:

> NLD04: A century is … usually a portion I guess it would be one tenth of a millennium, I think, what is it usually, um, *every one to two hundred years*.
>
> NLD13: [discussing *noon*] Most commonly known as 12:00 *a.m.*
>
> NLD20: I think it's an amount of time, but I don't know how much time.

On an EVT-2 item that was similar to *bashful,* participants in both clinical groups were more likely to use close but slightly imprecise synonyms like *clingy*, *quiet*, *hesitant*, or *waif-like*. Similar errors on other items included *strenuous* as a synonym for *challenging*; *compassion* for *excuse; rebellious* for *rude; precocity* for *talent;* and *verify, verisimilitude* for *genuine.* Other imprecise responses were phonologically similar, for example: *discern* as a synonym for *discuss*, *daddle* for *dawdle, extrude* for *exude*, *simplify* for *signify*, *shrapnel* for *shard,* or *utilities* for *utensils*. None of the control participants made similar mistakes. Other examples of imprecise responses produced by participants with NLD and ASD during data collection were phrases such as *a way to calculate objects*, *to enjoy our leisurely time*, *when you ask or inquisit*, *to enlighten the mood, unorderly conduct at the scene, something that omits a sound, varying sizes of water, the plutonic family dream, some form of person, a freeze that resumes back*, *to conform to music,* and *something unhidden*.

Unusual semantic representations for visual-spatial concepts occurred more frequently for the NLD than either the ASD or control participants, including errors in language describing shapes and visual-spatial relationships. Two participants with NLD made an error in distinguishing between pictures of twins, triplets, quadruplets, and quintuplets on the PPVT-2, in which participants choose one of four illustrations that best depicts a word. Another participant with NLD made the same mistake, but carefully counted the number of people in each of the pictures a second time and caught the error. Two more adults with NLD and one with ASD labelled a basic geometric shape as another, similar shape. None of the control participants made these mistakes. Elaborations that produced errors on Vocabulary for participants with NLD were also indicative of visual-spatial confusions:

> NLD08: Sentence: a sequence of words going in a logical order, usually *right to left*.

> NLD05: It's a circle [describing a spherical object].

> NLD11: I don't want to say spherical [describing a spherical object]… an *ellipsoid* [a term for a circular, two-dimensional surface or plane].

There were also observable instances of difficulties with semantic integration in both clinical groups. A participant with NLD was attempting to define *impression* without success. The participant noted having used the term frequently in everyday conversation, but as he expanded on his definition it became evident that he was trying to explain the meaning of *impress*. Separating root words from modifiers was not uncommon during data collection. There were four items in the latter third of Vocabulary that were less familiar to all participants. These items lent themselves to being broken down into morphemes, or smaller syllables with known meanings. Participants with NLD and ASD made errors in recombining morphemes. For example, using his knowledge of *re* as a prefix that indicates repetition, a participant with ASD defined *report* as a thing that tells about or summarizes, *over and over*. This participant's performance on both of the gestalt perception measures was well below the sample mean, supporting the informal evidence of weak gestalt perception in both formats. None of the participants in the Control group made the same error.

3.1.4   Discussion

Results supported the hypothesis that adults with NLD and ASD would not differ from those without a diagnosis in the overall breadth of their vocabulary or their scores for verbal reasoning, but that qualitative differences in depth, detail, formality, and precision would be demonstrated in both clinical groups (Stothers & Oram Cardy, 2012). Group means were not statistically different for any of the standardized verbal measures in the present sample, supporting the first part of the hypothesis. Observations supported the second part of the hypothesis, in both clinical groups. Unusual responses were widespread in these groups as compared with control participants.

There were no mean group differences on Similarities, the test of verbal reasoning; all three groups had scaled scores at the upper end of the average range. This result supported clinical characterizations of individuals with NLD and ASD as having verbal strengths at the group level. The result also provided evidence against an interpretation that lower scores on any of the measures in the experiments to follow, particularly those of semantic integration, would have been attributable to generally lower verbal intelligence in either of these groups. The Vocabulary and Similarities subtests were drawn from the same battery of IQ measures, making a comparison of subtest scaled scores reasonable.

The other co-normed test comparison, between the EVT-2 and PPVT-4, also found no differences. The pattern here was consistent with a follow-up study with 60 adults with autism, where changes from early to late adulthood in expressive and receptive language were seen to be roughly equivalent (Howlin et al., 2014). It was also in line with a recent meta-analysis of vocabulary knowledge in ASD children (Kwok, Brown, Smyth, & Oram Cardy, 2015), in which no overall trend for better expressive than receptive vocabulary was found. These findings did not depend on data collection methods, estimates of nonverbal IQ, the age at which diagnosis occurred in the participants, or whether participants were included based on gold standard ASD measures.

Observationally, there were numerous examples of unconventional responses in NLD and ASD participants. Some of these words were more sophisticated than those used by the majority of control participants, and were therefore suggestive of especially diverse lexicons in some participants in the clinical groups. Although qualitative differences have been labelled as weaknesses in the literature, atypicality can be both negative, in the sense of deviance, and positive, as in remarkable or astonishing. Instances of uncommon vocabulary may manifest as overly formal language, a disadvantage in casual conversation that may be an advantage in professional settings. Exceptional semantic memory has been identified as a source of success by academics, for example, who have ASD (Anonymous, 2105; Boucher, 2007). Similar examples of positive outcomes were not found for adults with NLD in the literature. Nonetheless, there appeared to be no

difference in the degree to which responses were unusual in adults with either NLD or ASD in the sample. As noted above, this possibility will be explored further.

Quantifying uneven performance has been a challenge for researchers (Corrigan, 2008; Paul & Wetherby, 2005; Worth & Reynolds, 2008). Vocabulary errors here were sporadic, and took place in the context of average to above average or superior word knowledge as measured by standardized vocabulary tests. These tests were untimed, and did not track or limit length of response, frequency of word repetition, number of main ideas versus correct but irrelevant responses, or semantic errors that do not affect the meaning of the response. The examples provided here illustrated that participants with NLD and ASD provided non-target content in their responses, suggesting that their semantic representations were perhaps less precise than high test scores might otherwise indicate. As a participant with ASD said when defining *intermediate*: "I don't know. It's similar to *intermission*. When I was a kid I heard so many words that I did not understand, and I figured someday I would understand them." The phonological rather than semantic similarity between the words the participant was comparing was notable. This example was consistent with a study of fluency in adults with ASD, in which access to words was stronger by phonological than semantic association (Spek, Schatorjé, Scholte, & van Berckelaer-Onnes, 2009).

The source of differences in the quality of semantic representations has generated speculation, if not empirical research. The development of semantic representations is by its nature integrative (Clark, 2014; Coulson, 2006), suggesting a potential barrier for individuals with NLD and ASD because of suggestions in other research of integrative processing being disrupted at the neural level (Collins & Rourke, 2010; Kana et al., 2013; Wass, 2011). Whether integration difficulties would be seen in the present sample was examined in Experiment 2, described next.

3.2   Experiment 2: Visual-Spatial Ability, Gestalt Perception, and Semantic Integration

Having established that the three groups of participants did not differ in the breadth of their vocabulary, the next step in examining semantic integration was to consider gestalt

perception, an underlying cognitive function required to make connections between unlike semantic representations, as discussed in the Introduction (e.g., Bell, 1991; Coulson, 2006; Fauconnier & Turner, 1998; Jung-Beeman, 2005). Low scores on nonverbal tests of gestalt perception have been reported in both disorders, and difficulty with verbal gestalts, such as extracting gists in conversation and understanding metaphors, has also been seen (Gold et al., 2010; Gross-Tsur et al., 1995; Happé & Booth, 2008; Jolliffe & Baron-Cohen, 1999; Landa, 2000; Palombo, 1993; Stothers & Klein, 2010). It has yet to be widely established that such difficulties are related, but my Master's research found that a perceptual organizational test from the Wechsler Adult Intelligence Scale (WAIS) and a test of gestalt closure predicted a large proportion of variance in reading comprehension (Stothers & Klein, 2010). The relationship was very strong, despite the contrasting formats of the nonverbal predictor and verbal criterion variables; nonverbal measures accounted for more variance in reading comprehension scores than did word knowledge or phonological awareness.

Similarly, a recent study of another developmental disorder, Williams syndrome, found statistically significant correlations between a standardized measure of perceptual integration and metaphor comprehension, but not between metaphor comprehension and expressive vocabulary (Godbee & Porter, 2013). This study was of particular relevance because individuals with Williams syndrome have a linguistic profile that is similar to NLD, with stronger phonological awareness and breadth of vocabulary, relative to weaker pragmatics (Godbee & Porter, 2013; see also Rourke, 1995). In the reading comprehension study, both visual-spatial and gestalt perception abilities were related to the dependent language variables. In the Williams syndrome study, the only perceptual integration measure was one of visual closure, more plainly suggesting a link between gestalt processes and metaphor understanding. In the present study, gestalt perception was examined separately from visual-spatial skill, in order to determine whether either or both may affect semantic integration, and to what degree. These abilities have been well-studied in both disorders, as reviewed next.

As the label is meant to convey, cognitive deficits in NLD are non-linguistic. Aspects of nonverbal cognition and perception that have been found to be less well developed than

verbal abilities in NLD include visual and spatial perception, visual-spatial reasoning and working memory, and visual imagery (Cornoldi et al., 2003; Hendrikson et al., 2007; Mammarella, Coltri, Lucangeli, & Cornoldi, 2009; Mammarella & Pazzaglia, 2010; Semrud-Clikeman et al., 2010a); tactile-perceptual and visual-motor skills (Semrud-Clikeman et al., 2010a; Tuller et al., 2001); locating objects in space (Forrest, 2004); memory for faces (Liddell & Rasmussen, 2005); and executive functions (Fisher, DeLuca, & Rourke, 1997; Semrud-Clikeman et al., 2014). As this list demonstrates, the difficulties are widespread, but most individuals with NLD will not present with each of these weaknesses (Forrest, 2004; Rourke, 1989; 1995).

Perceptual integration has been studied extensively in relation to competing theories of perceptual differences in ASD (Happé & Booth, 2008; Mottron et al., 2006; O'Riordan & Plaisted, 2001). Some of these findings have been mixed. In contrast to individuals with NLD, who experience difficulty when stimuli used to test gestalt perception demand visual-spatial processes such as mental rotation, imagery, and working memory for spatial patterns, those with ASD may be better able to compensate. Visual-spatial skills such as detecting geometric shapes in complex visual arrays and constructing patterns from blocks have been described as better than average (Caron et al., 2006; McGrath et al., 2012; Shah & Frith, 1993; Wing & Gould, 1979; see Muth, Hönekopp, & Falter, 2014, for review), but relative weaknesses and below average performance have also been found (Barnhill et al., 2000; Chen, Lemonnier, Lazartigues, & Planche, 2008; Soulières, Dawson, Gernsbacher, & Mottron, 2011; Williams, Goldstein, Carpenter, & Minshew, 2005). Results have depended on the choice of nonverbal measures, their complexity, the specific abilities they are hypothesized to reflect, task instructions, and stimulus formats such as auditory or visual, static or dynamic, and social or non-social (Bertone, Mottron, Jelenic, & Faubert, 2005; Gunter et al., 2002; Kuschner, Bennetto, & Yost, 2007). Large scale studies and meta-analyses of visual perceptual abilities in ASD have also found that tests intended to measure a single cognitive construct have instead reflected various capabilities, with only moderate correlations between tasks (e.g., Milne & Szczerbinski, 2009; Pellicano, Mayberry, & Durkin, 2005). Samples that vary in terms of severity of symptoms and ASD subtype, a source of potential differences in cognitive and neuropsychological profiles (Kanai et al., 2012; Klin et al., 1995; Manijiova & Prior,

1999; Muth et al., 2014), may have also contributed to mixed findings, but heterogeneity has been seen even in samples restricted to those with Asperger syndrome (Caron et al., 2006). In sum, it appears that visual-spatial functions may be more variable in adults with ASD than they are in those with NLD.

It is also possible that inconsistent results in ASD have occurred in part because proficiency with visual-spatial reasoning has not been examined separately from gestalt perception. In the present study, these processes were separated as much as possible by using visual-spatial tests that differed in the degree to which gestalt perception was required for their successful completion. Sequential processing may assist an individual to piece together a gestalt array analytically, step by step or by trial and error, rather than apprehending the whole. Although tests that involve arranging blocks require visual-spatial manipulation, they also may be solved sequentially as participants build designs, block by block. In contrast, other visual perceptual tasks that were administered here (e.g., Object Assembly, Gestalt Closure, described below) require participants to identify objects without working from a template or known result. Items cannot be solved simply by joining fragments, so these tests require integrative processing. Comparing results for these tests permitted the separation of visual-spatial and gestalt processes, allowing for the expression of a potential difference between NLD and ASD participants. Similarly, a verbal test of semantic integration did not include explicitly visual-spatial concepts, in contrast to some of the test stimuli in the vocabulary measures used previously (see Observational results in Experiment 1 for examples). Items were three-word association tasks that were literal and metaphorical, concrete and abstract, and did not require visual-spatial reasoning. Scores for the test were also compared to baseline vocabulary findings, as well as to the perceptual reasoning tests, to quantify the strength of these correlations in the sample.

3.2.1 Research Question and Hypothesis

This experiment examined the question: Are weaknesses in gestalt perception and formation common to adults with NLD and ASD relative to controls, and demonstrable in both nonverbal and verbal formats?

The hypothesis was that verbal and nonverbal tests of gestalt perception would be more difficult for adults with NLD and ASD than for the Control group, but that the clinical groups would not differ from one another. In order to isolate the gestalt perception demands of a nonverbal task from the visual-spatial and fine motor abilities that the test also requires, one measure of each of these skills was also administered.

3.2.2   Method

The same group of adults described in Experiment 1 participated in Experiment 2. Procedure and data analysis were also as above.

3.2.2.1   Materials

3.2.2.1.1 Gestalt Perception

Measures of gestalt perception were (a) Object Assembly, (b) Gestalt Closure (Kaufman & Kaufman, 1994), and (c) Remote Associate Problems (Bowden & Jung-Beeman, 2003). Object Assembly requires participants to put together puzzles of three to nine pieces within one to three minutes, depending on the difficulty of the item. Object Assembly is a measure of gestalt perception because the identity of the object depicted in the puzzle is unknown. In contrast, the visual-spatial comparison measure, Block Design (see below), includes templates from which to work. Three of five Object Assembly items were drawn from the Wechsler Adult Intelligence Scale, Third Edition (WAIS III; 1997) Object Assembly subtest, and an additional five were drawn from an updated version of the test that is normed only for children up to the age of 7 (Wechsler Nonverbal Scale of Ability, Wechsler & Naglieri, 2006), so standard scores and reliability data were not available Evidence for convergent validity for the use of this test here was found. In a large sample of adolescent boys (Cederlund, 2007), a standardized administration of Object Assembly found 38%, or 35 of 92 participants with Asperger syndrome had a scaled score below the 16th percentile. Mean scores for Object Assembly were lower than were scores for Vocabulary and Similarities. Below average to borderline scores for Object Assembly have been used to define and describe NLD in children and in adults (Humphries et al., 2004; Liddell & Rasmussen, 2005; Rourke, Del

Dotto, Rourke, & Casey, 1990; Tuller et al., 2001). It was expected that the clinical groups would have lower mean scores for this measure than the controls. No differences between ASD and NLD groups were anticipated.

Gestalt Closure is a visual closure test in which participants are shown black, yellow, or black and yellow pictures of objects on a white background. Sections of both the interior and the silhouette have been removed from each image, so that the images are fragmentary. The dependent variable is the number of correctly identified pictures out of a total of 25. Objects to be identified are made up of more than the parts that appear on the page–a gestalt process that has been found to be difficult for individuals with NLD (Gross-Tsur et al., 1995; Stothers & Klein, 2010), and would be expected to be so according to WCC for those with ASD. One study that used this measure was found, but a mean score for the group with ASD was not reported (South, Ozonoff, & McMahon, 2007). The technical manual for the battery of tests from which Gestalt Closure was taken reported split-half reliability coefficients from .82 to .87 for adults (Kaufman & Kaufman, 1994). The same prediction regarding Object Assembly was made for Gestalt Closure.

In Remote Associate Problems, participants search for an unknown word to combine with stimulus items, forming three new semantic representations that share the solution word (e.g., cream / skate / water = ice; see Appendix A). Twenty-four items with solution rates spanning 20% to 80% were chosen from a set of items with normative data for a university-educated group of respondents (Bowden & Jung-Beeman, 2003). Lower mean scores for clinical groups than the Control group were again expected, on the basis of problems with semantic integration reviewed in the Introduction.

3.2.2.1.2 Comparison Tests

Two additional tests, (a) Block Design (Wechsler, 1999) and (b) Grooved Pegboard (Trites, 1997), were used to separate gestalt perception from visual-spatial reasoning and motor speed, respectively. Block Design requires participants to arrange red, white, and half-red, half-white blocks in abstract patterns, copying designs to which they have

access while they complete the test. Limits of one minute for four block patterns and two minutes for nine block patterns are imposed. Performance on Block Design relies on visual-spatial abilities that are weaknesses in NLD and are less consistent in ASD, as described above. It was therefore expected that a Controls > ASD > NLD pattern would emerge for this test.

The Grooved Pegboard test (Trites, 1997) was given to measure manual dexterity, which also influences scores for Object Assembly and Block Design. The test requires participants to place metal pegs into a board sequentially, with the dominant or preferred hand first, and then the other. The pegs have a notch running their length, and slots in the board are shaped to receive them. The slots vary in orientation, requiring participants to rotate the pegs in order to fit them into the slots. The speed at which 25 pegs are inserted is timed for each hand; higher scores indicate slower peg placement. All participants began with their self-reported preferred hand, and completed a second trial with their non-preferred hand. Because fine motor deficits coincide in NLD and ASD (Gillberg & Billstedt, 2000; Nydén et al., 2010; Semrud-Clikeman et al., 2010a), a Controls < ASD = NLD pattern was expected for Grooved Pegboard.

3.2.3   Analyses

Group mean scores for the dependent variables were compared with one-way analyses of variance. Correlations between variables were calculated to ensure linear relationships, a requirement for regression analysis. Linear regression analysis was completed for Object Assembly to estimate the influence of the Block Design, Grooved Pegboard (Preferred hand), and Gestalt Closure variables across the sample. Although regression analyses are best performed on larger data sets (SPSS, 2013), statistics for tolerance, variance of inflation, and condition indices all indicated little overlap between variables, or multi-collinearity. As well, the order in which predictor variables were entered into the model did not affect results, indicating a reasonably robust model (Hair & Black, 2000). Observations during manual tests were reported as well.

3.2.4   Results

Assumptions regarding homogeneity of variance across variables were examined. One
outlying score was found in the NLD group for Grooved Pegboard on both trials. Log
transformation normalized the Non-preferred hand score, but not the score for the
Preferred hand, so this participant's scores for Grooved Pegboard were removed. The
remainder of the dependent variables were normally distributed, and no other changes
were made to the data.

3.2.4.1   Quantitative Results

Object Assembly, one of two nonverbal integration measures, showed between-group
mean differences, $F(2, 54) = 22.62$, $p < .001$, with significant differences for both the
clinical groups on post hoc analysis, and large effect sizes (Table 3-5). There was a small
difference in effect size in favour of the ASD over NLD group for Object Assembly, $d =$
.36. A second nonverbal measure of perceptual integration, Gestalt Closure, did not
produce significantly different group means, although the Control higher than NLD group
mean comparison had a moderate effect size, $d = .61$. This unexpected result may have
been due to non-standard administration of the test (see Discussion). The two highest
scores in the sample on Gestalt Closure occurred in the NLD group.

The comparison tests showed significant mean group differences on analysis of variance
for Block Design, $F(2, 60) = 12.13$, $p < .001$. On post hoc analysis, both the Control and
ASD group means were significantly better than the NLD group mean, $p < .001$ and $p <$
.01 respectively, with large effect sizes, $d = 1.26$ and $d = .93$. The Control versus ASD
comparison was not significant, producing a small effect, $d = .33$, in favour of the
Controls. Score variability was greatest in the ASD group, with a range of 8-16 for Block
Design scaled scores. The standard deviation was 2.29, in comparison to 1.48 in the
Control group and 1.69 in the NLD group.

Clinical groups had similarly slow completion times for Grooved Pegboard in
comparison with the Control group, with significant differences for both Preferred and
Non-preferred hand completion times. For the Preferred hand, the Control versus ASD

effect size was slightly larger, $d = 1.01$ than the Control versus NLD difference, $d = .92$. For the Non-preferred hand, the NLD group's effect size in comparison to the Control group was smaller, and only moderate, $d = .67$. The large effect size for the Controls versus ASD did not change, $d = 1.05$. On post hoc analysis, there was no difference between the ASD and NLD groups, with an almost identical result for the preferred hand, $d = .09$, and a small difference for the non-preferred hand, $d = .38$. This data excluded the outlier scores for one of the NLD participants. There was no difference between groups for a Preferred minus Non-Preferred hand variable, $F (2, 58) = 1.36$, n.s.

Table 3-5: Group mean comparisons for dependent and predictor variables

Variable	Comparison	mean diff (s.e.)	95th %ile CI (lower, upper)	d	p
Remote Associates	Control = ASD	-.10 (1.06)	- 2.74, 2.55	.02	n.s
$F (2, 60) = 5.46$,	Control > NLD	3.19 (1.14)	.34, 6.04	.81	< .02
$p < .01$	ASD > NLD	3.29 (1.19)	.31, 6.26	.84	< .02
Object Assembly	Control > ASD	19.38 (3.73)	10.17, 28.59	1.23	< .001
$F (2, 53) = 12.80$,	Control > NLD	24.70 (3.88)	15.10, 34.30	1.60	< .001
$p < .001$	ASD = NLD	5.32 (3.84)	- 3.79, 14.42	.35	n.s
Gestalt Closure	Control = ASD	.23 (.82)	-1.79, 2.24	.09	n.s
$F (2, 59) = 1.94$	Control = NLD	1.48 (.81)	-.51, 3.46	.56	n.s
n.s	ASD = NLD	1.25 (.83)	-.76, 3.26	.47	n.s.
Block Design	Control = ASD	.71 (.56)	-.78, 2.21	.33	n.s.
$F (2, 60) = 12.13$	Control > NLD	2.71 (.49)	1.49, 3.94	1.26	< .01

p < .001	ASD > NLD	2.00 (.62)	.45, 3.55	.93	< .01
GP Preferred	Control < ASD	13.97 (5.79)	3.63, 24.31	1.01	< .01
F (2, 60) = 7.87,	Control < NLD	18.07 (6.23)	2.00, 34.13	9.92	< .05
p < .001	ASD = NLD	4.10 (6.99)	13.53, 21.73	.09	n.s
GP Non-preferred	Control < ASD	16.55 (4.96)	3.81, 29.28	1.05	< .01
F (2, 60) = 6.91,	Control < NLD	15.20 (5.55)	.92, 29.47	.67	< .01
p < .002	ASD => NLD	1.35 (7.03)	- 16.22, 18.92	.38	n.s.

Note. Effect sizes were calculated using the pooled standard deviation of the sample, therefore effect sizes reflect simple differences between group means. Mean diff = mean difference; GP = Grooved Pegboard.

Remote Associate Problems did demonstrate a mean group difference, $F(2, 60) = 5.46$, $p < 01$. On post hoc analysis, both the Control and ASD groups had significantly higher mean scores than that of the NLD group, with effect sizes in both cases over .8, ormoderate to large. There was no difference between the mean scores for the Control and ASD groups.

Scores for the Preferred hand completion of Grooved Pegboard were negatively correlated with all other dependent variables, including Remote Associates and the vocabulary measures from Experiment 1 (Table 3-3, Experiment 1). On regression analysis, the nonverbal tests given to isolate the effects of visual-spatial and fine motor skills from Object Assembly did significantly predict scores across the sample, $F(3, 49) = 9.71$, $p < .001$, $r^2 = .26$, but only group status predicted Object Assembly scores, $\beta = .55$, $t = 4.43$, p < .001. Neither the Preferred nor the Non-preferred hand scores for Grooved Pegboard contributed significantly to the model, $\beta = .025$, n.s., and $\beta = -.25$, respectively (Table 3-6).

Table 3-6: Goodness of fit statistics for object assembly regression analysis

Variable	Object Assembly		
	B	*t*	*p*
Grooved Pegboard (preferred hand)	-.03	-.22	n.s
Group	.53	4.27	< .001
Gestalt Closure	.17	1.62	n.s
Block Design	.13	1.01	n.s.
Model	$R = .69$, R^2 adj = .44, $F(4, 50) = 11.42$, $p < .001$		

3.2.4.2 Observations

Observation of performance on the nonverbal measures suggested the influences of poor visual memory and perseveration in the clinical participants, in addition to problems with gestalt perception. For example, a participant with NLD was unable to remember the

pattern in which he should place pegs on the Grooved Pegboard test after the initial instructions, a reminder, and a second instruction for the Non-preferred hand. On Object Assembly, participants with NLD and ASD were observed to solve puzzles correctly, in terms of the configuration of pieces, without being able to identify what they were seeing. For example, one participant said that an animal was a ship; although he rotated the puzzle 180 and then 360 degrees, his solution was upside down and incorrectly named. Others were able to identify the puzzle as an animal, but could not finish placing the last one or two pieces because their canonical mental image did not match the pose in which the animal was depicted (e.g., if the puzzle was a dog with drooping ears, some participants pictured a dog with ears standing and could not place the ears correctly). This did not occur in any of the Control group participants. Despite average range scale scores overall for Block Design, a handful of participants in both of the clinical groups, but not the controls, made unusual errors on the nine block puzzles. In one instance, the final configuration of blocks produced by a participant with ASD was not a quadrilateral (a square or diamond), as are all of the correct solutions in this version of the WASI. Instead, the participant arranged the blocks without an overall, identifiable shape, and stated that he was satisfied with his solution.

3.3 Discussion

Both the NLD and ASD groups had significantly different mean scores on the nonverbal gestalt perception measure, Object Assembly, that were lower in comparison with the mean score for the Control group. This result could not be explained solely by characteristic weaknesses in NLD such as mental rotation and spatial visualization, as only the group with NLD had significantly weaker mean scores than did the Control group on Block Design, a measure of visual-spatial abilities. The fact that both clinical groups also had relative difficulty on the Grooved Pegboard test might have suggested that their performance on Object Assembly was related to slowed motor speed rather than weaker nonverbal integration, but again, the difference between the NLD and ASD groups for Block Design argued against this possibility; that is, there is no reason to believe that fine motor impairments would lower scores for Object Assembly but not Block Design. Object Assembly was as strongly correlated with Remote Associate

Problems and Block Design as it was with the Grooved Pegboard results (Table 3-3, Experiment 1). An alternative explanation was that low scores for both groups were indeed related to difficulties with gestalt perception. To complete Object Assembly, participants identified the object they were making from emerging relationships between unlike pieces. Participants in both clinical groups demonstrated difficulties finishing puzzles with only one or two pieces out of place. The difficulty with one of the animal puzzles that was noted by Myklebust (1975) in a case study of a boy with NLD was also seen in individuals with NLD and ASD here, suggesting a shared difficulty with gestalt perception.

In Block Design, configural relationships between like pieces and the overall, abstract form were directly in front of participants as they assembled the puzzle, and there was no need to form a gestalt. In fact, creating verbalizable forms from abstract Block Design patterns would have been a hindrance to completing the test (Shah & Frith, 1993). These researchers, and others who have found similar results (Best, Moffat, Power, Owens, & Johnstone, 2008; Ehlers et al., 1997; Happé, 1994; Spek et al., 2008), proposed that seeing a meaningful pattern interferes with the effort to segment the design into individual blocks so that each block could be mapped correctly by colour and orientation onto the template. This interpretation was based on the finding in Shah and Frith (1993) that individuals without ASD benefitted from the presentation of a template that was already segmented, block by block, while scores for those with ASD were not appreciably different from their scores for unsegmented patterns.

Results of a pilot study conducted prior to these studies found the same pattern (Stothers & Oram Cardy, 2010). A difference score representing results for non-segmented block designs subtracted from results for a segmented version was significantly higher for the NLD and control participants than for the participants with ASD. Following Shah and Frith's interpretation (1993), it appeared that the NLD and control participants in the smaller sample used a step-by-step strategy for the segmented designs that resulted in improved scores. In contrast, ASD participants appeared to use this approach for both sets of stimuli, given that their scores were not higher for segmented block designs. In other words, the strategy of building solutions sequentially was adaptive in Block Design,

but it appeared to be less effective in solving puzzles such as Object Assembly. In Object Assembly, puzzle pieces may seem to fit, but if they are aligned in ways that do not create an identifiable object, the solution is incorrect. If participants finish assembling the puzzle correctly but cannot name the object, only points for correctly joined pieces are counted, and no extra points are awarded based on completion time. Identifying the object, or perceiving and naming the gestalt, was thus interpreted as the critical factor in producing the difference for the ASD group between their scores on Block Design, which were no different from controls, and their scores for Object Assembly, which were lower than controls.

Observation suggested that participants with NLD also struggled with identifying the target objects as they worked. Whether participants with NLD had to work against perceiving identifiable forms in the Block Design templates was unknown, as their difficulties with mental rotation, visual-spatial working memory, visualization, and fine motor speed would seem to be enough on their own to lower their Block Design scores relative to the Control and ASD groups. Difficulties with rotating and orienting blocks were observed, but were not reflected to the degree that might have been expected in the scaled scores. The overall mean scaled score for the NLD group on Block Design was in the average range, and only five of the 21 participants had scores at or below the 25th percentile, or the low end of the average range. All participants, however, had completed Block Design at least once before during psychoeducational assessments for diagnosis. Thus, it was not possible to estimate the influence of familiarity on the Block Design scores for the NLD group. Nonetheless, their scores were lower than the other groups, and lower than their mean Vocabulary score. The mean for the NLD group was also in line with other research, in which scores up to the 50th percentile have been seen in combination with lower Object Assembly scores (Buitelaar, Swaab, van Der Wees, Wildschut, & van der Gaag, 1996; Weintraub & Mesulam, 1983; see Mammarella & Cornoldi, 2014, for a review).

Results for Grooved Pegboard supported the contention that NLD is characterized by weaker performance on this task (Pelletier et al., 2001), and the inclusion of fine motor deficits as a defining characteristic in ASD (Jansiewicz et al., 2006; Ryburn et al., 2009;

Szatmari, Tuff, Finlayson, & Bartolucci, 1990). The results did not support lateralization of fine motor deficits in NLD, as hypothesized by Rourke (1989; 2000). Results also were not consistent with a recent study of children with NLD, defined primarily by low scores for social perception and mathematics performance, whose performance on Grooved Pegboard was not statistically different from children with inattentive ADHD or controls (Wilkinson-Smith & Semrud-Clikeman, 2014). Unimpaired performance in their study compared with impairments in the present sample was also inconsistent with a paper in which the authors commented that difficulties with fine motor skills may resolve as children with NLD mature (Pelletier et al., 2001). Thus, it seemed unlikely that contrasting results were due to age. A more likely possibility was a difference in sample size, as all three groups and the overall sample were larger in the present study.

Lower mean scores for Object Assembly in the two clinical groups supported the hypothesis that gestalt imperception is a common weakness in NLD and ASD, beyond the influence of visual-spatial or fine motor skills. The same result was not found for the other nonverbal measure of gestalt perception, Gestalt Closure. This was unexpected, as were lower scores for the Control group, four of whom scored at or below the 25th percentile for this test. Although the standardized administration of the test permits unlimited time to respond, whether or not participants answered in less than 10 seconds was recorded. This choice was not made explicit to participants, but may have nonetheless added a time pressure to their performance. The same measure was used in the study reported next (Chapter 4) without recording completion times, and significant clinical versus control group differences were seen. Again, some of the participants in the NLD group had completed Gestalt Closure before as part of having a psychoeducational assessment for diagnosis, and it was unknown whether they had received feedback after doing the test. One of the participants in the NLD group had the highest scaled score in the sample, and another very high score for a participant with NLD affected the results of the analysis of variance to a degree that suggested the need for a sample of 25 or more participants, as indicated by the power analysis described earlier.

As expected, then, both clinical groups showed weakness in gestalt perception, although on only one of the nonverbal measures. The non-significant comparison for Gestalt Closure results between the Control and NLD groups may have been influenced by practice effects, but this explanation could not be applied to the participants with ASD. It was unknown what other cognitive processes might differentiate Object Assembly from Gestalt Closure, as the results for Block Design ruled out weaker fine motor skills in the clinical groups as a critical difference. Despite their lower scores for Object Assembly, the ASD group had a mean scaled score at the 50th percentile for Gestalt Closure, and as a group were thus not at all impaired in their performance. Score variability and heterogeneity in both of the clinical groups, particularly in those with ASD, has been seen in other studies comparing cognitive and neuropsychological measures (Geurts et al., 2014; Hagberg et al., 2013; Milne, 2011; Wilson et al., 2014).

Mean scores for Remote Associate Problems were significantly different between groups, with the NLD group having lower scores than both the ASD and Control groups. This finding could not be explained by differences in single word knowledge or general ability to reason with language in adults with NLD. Instead the result supported the hypothesis that the interpretation of meaning was impaired by difficulty with integrating discrete word meanings into a new semantic representation. That the NLD group had particular difficulty with Remote Associates also echoed Rourke's assertion that difficulty with novelty is a primary neuropsychological deficit in NLD (1989; 1995; 2000). A lower mean for the NLD group was in line with expectations, but the higher mean score for the ASD group was not. As was the case for the other integration measures, scores for the ASD group in particular were variable: four of the five top scores for Remote Associates across the sample were recorded for participants with ASD, as was one of the five lowest scores.

The performance by the ASD group as a whole on Remote Associate Problems was consistent with a study (Norbury, 2005b) in which two groups of children with LI, one with co-occurring ASD and one without, were less efficient than an ASD-only group and a control group in resolving the meanings of ambiguous words. Word meanings differed according to surrounding context (e.g., river bank versus bank teller), with tasks that

required disambiguation using complete sentences and pictures. Autism symptoms were not associated with contextual integration difficulties; rather, the presence of structural language impairment, only, was associated with less efficient resolution of ambiguous words. Neither participant self-reports nor overall scores for vocabulary tests were indicative of LI in any participants in the present sample, making the lack of difficulty with Remote Associates for the ASD group less surprising from the standpoint of Norbury's findings. Another feature of the study by Norbury (2005b) with which the present results are in part consistent was that both groups of children with LI had significantly lower scores for the WASI Performance index, which is made up of Block Design and a visually based set of pattern recognition problems, the Matrix Reasoning subtest. The NLD group here also had significantly lower scores for Block Design than did the ASD and Control groups, as well as lower scores for Remote Associates. The NLD group did not, however, have signs of LI, although early language history and additional structural language measures were not included. Results throughout the current thesis suggested that the presence of weaknesses in perceptual reasoning may have a negative influence on vocabulary.

Solutions to Remote Associates problems may have been sensitive to the influence of formulaic language as well as semantic integration. For a problem to be solved, participants had to have some familiarity with all three two-word expressions (e.g., *game piece*, *mind game,* and *dating game*) that the solution word (i.e., *game*) produced. Individuals with ASD and NLD have been reported to use fixed phrases repeatedly (Dobbinson, Perkins, & Boucher, 2002; Happé, 1991; Noens & van Berckelaer-Onnes, 2005; Rourke & Tsatsanis, 1996), and the interpretation of EEG results for idiom identification outlined above (Strandburg et al., 1993) also suggested a reliance on formulaic language in adults with Asperger syndrome. The performance of the ASD group raised the question of whether these adults have strengths with memorized *collocations,* or fixed two-word expressions (Molinaro & Carrieras, 2010). If so, it is possible that they may be a developmental outcome of *echolalia*, an early imitative tendency in language production that lasts longer in children with ASD than it does in typical children (Dobbinson et al., 2002; Eigsti, de Marchena, Schuh, & Kelley, 2011; Noens & van Berckelaer-Onnes, 2005). If adults with ASD have a larger repository of

collocations, performance on Remote Associate Problems would be expected to be strong, independent of any possible weaknesses in their semantic integration abilities.

Observationally, this seemed like a good possibility. Participants with ASD were notable for their use of collocations in conversation and on the word definition tasks, although frequency counts were not recorded. One participant consistently used a meaningless phrase, *the very thing that* or *the very word that*, in approximately 25% of his responses to the Vocabulary items. In correctly defining a word that the majority of participants could not, another participant with ASD added *what's good for the goose is good for the gander*. However, this adage was unrelated to the meaning of the word he had just defined, which was comparable to *remedy*. Similarly, another participant with ASD commented that *an object in motion always stays in motion* after defining a word similar to *ball*. The possibility that contrasting processes were underlying performance suggested that semantic integration should be studied with other measures that might be less sensitive to familiarity. A true measure of semantic integration produces novel, or unfamiliar, products (Gold et al., 2010; Gunter et al., 2002). The second stage involved in correctly solving Remote Associate Problems, in particular, was inconsistent with this feature of semantic integration. Checking that a particular word was appropriate to each of the individual test stimuli was more a confirmation of relatedness than it was finding an emergent, novel property. That the two clinical groups differed on this measure is nonetheless of interest, and will be explored further.

Observations in Experiment 1 also suggested difficulties in semantic integration for both clinical groups, including semantic errors on the vocabulary tests that could not be attributed to visual-spatial confusions. Some of the less familiar items on WASI Vocabulary were root words modified by prefixes, which some participants in the clinical groups were able to parse but did not recombine successfully. The example given above was *report*, which a participant with ASD defined incorrectly as "to tell or summarize, over and over," in apparent reference to his understanding of the meaning of the prefix *re*. A misapprehension of this kind would not necessarily be corrected in conversation. For example, in saying "the report I wrote was accepted," the speaker may intend to express his or her experience of having written many drafts of a document, but that

intention would not affect the listener's understanding of the decision concerning the report. In my clinical experience, this type of error was more apparent in the post-secondary educational setting because of the need for words to be used precisely. During data collection, participants in all three groups repeated words aloud and referred to the test booklet as they responded; failing to include morphemes such as *pre*, *im*, *re*, was unlikely a function of a deficit in auditory working memory. Instead, these observations were more consistent with studies that found semantic integration weaknesses in ASD participants (Gold & Faust, 2010; Gold et al., 2010; Joliffe & Baron-Cohen, 1999), and with the significant difference in scores for Remote Associate Problems in the NLD group.

3.4   Summary of Experiments 1 and 2

In general, hypotheses were supported. The clinical groups were not statistically different from the Control group on co-normed tests of word knowledge and verbal reasoning, or on the co-normed tests of receptive and expressive language. As well, there were no statistically significant differences between the NLD and ASD groups for these measures. Some, but not all, of the clinical participants demonstrated above average or superior vocabulary, showing more breadth than is typical. In this sense, the clinical characterization of vocabulary strength in NLD and ASD was supported. At the same time, there were instances of imprecision and the suggestion of more shallow semantic representations in the clinical groups. Observations made during data collection made it apparent that available standardized testing does not adequately identify potential differences in semantic representations.

Both clinical groups demonstrated difficulty with gestalt perception, but this was more pronounced in the NLD than ASD group. In the ASD participants, only Object Assembly scores were notably impaired in comparison with Controls. Block Design was more similar than not to the Control group, by descriptive statistics such as range and mean scores, consistent with results for Block Design as an islet of strength (Shah & Frith, 1993). Nonetheless, standard deviations were larger in the ASD group for Block Design and for Grooved Pegboard. Some participants in the ASD group had scores on all

measures that were more similar to those typical of the NLD group, and vice versa. The separation between Object Assembly and Block Design in the clinical groups also reinforced the hypothesis that gestalt perception impairments were separable from fine motor and visual-spatial skills. Further examination of potential differences in gestalt perception should include multiple measures reflecting a range of visual-spatial abilities that isolate the influence of spatial and visual reasoning from the perception of gestalts.

Although observation suggested the hypothesized semantic integration difficulty in some participants with ASD, scores for Remote Associate Problems did not support this. In fact, some of the participants in the ASD group were unexpectedly good at these puzzles. On the other hand, weaknesses in both gestalt perception and visual-spatial skills appeared to affect language in adults with NLD. The latter finding was explored more fully in the study described next.

Chapter 4

4 Depth of Semantic Representations in Adults with NLD

As described in the Introduction, NLD is most easily understood as a disorder of non-linguistic capabilities. Verbal abilities are stronger in both children and adults, either intra-individually, or in some cases, as compared to the population in general (Stothers & Oram Cardy, 2012; 2016; Tsatsanis & Rourke, 2003). The results of the previous study, however, found that language is more variable in NLD than a simple contrast between weak nonverbal and strong verbal abilities might suggest. Language difficulties seen in the adult sample with NLD extended beyond pragmatic weaknesses documented in reviews and clinical observations (e.g., Davis & Broitman, 2011; Palombo, 2006; Myklebust, 1983; Ris et al., 2007; Semrud-Clikeman & Glass, 2008; Tsatsanis & Rourke, 2003). Rourke, in particular, referred to the presence of *cocktail party syndrome* (CPS; e.g., Tsatsanis & Rourke, 1996), a term that has been used descriptively, but has neither been supported nor discounted by experimental research. Rourke also used the phrase *content disorders*, perhaps referring to atypical utterances such as *to enjoy our leisurely time; to enlighten the mood;* or *the plutonic family dream* that were observed in the second study. Content disorders may be an apt description for these phrases, but the term does not also encompass knowledge and appropriate use of less familiar words such as *ersatz* or *riparian*. A plausible account of these contrasting but contemporaneous qualities of semantic representation in NLD has yet to be proposed.

Semantic representations are formed by the integration of a wide variety of information. Sensory percepts such as colour, odour, size, shape, texture, and weight add depth to lexical entries for physical objects, as does affordance information, or information about the ways in which objects may be used (Andrews et al., 2009; Eigsti, 2013; Gupta & Tisdale, 2009; Ross, 2010). The earliest case studies of NLD described impairments to organizing and reasoning about this type of perceptual experience (Johnson & Myklebust, 1967; Myklebust, 1975). Consequently, it has been suggested that children with NLD fail to add layers of meaning to semantic representations, built through sense and affordance experiences, because perceptual weaknesses limit their ability and motivation to explore the environment (Myklebust, 1975). In Rourke's elaboration (1999), a host of

new terms may be linked with a single experience of information-seeking: *Is this thing alive, quiet, soft, heavy, slippery, edible, salty, colorful, round, or dry; can I move it, open it, smell it,* and more. Labels can be learned, however, without fully exploring the objects to which they refer. With less exploration, new lexical entries have less information attached to them, and semantic representations are impoverished (Andrews et al., 2009). As they mature, children with NLD are said to rely on verbal problem-solving because of their nonverbal weaknesses (Rourke & Tsatsanis, 1996) and because adults appreciate children for whom they seem not to have to adjust their speech. Positive feedback from adults and good achievement at school (Foss, 1991; Mamen, 2007; Palombo, 2006; Ris & Nortz, 2008) may lead to a reliance on long-term memory for labels, rather than mutable and flexible semantic representations that have more depth. Once established, imprecise or shallow representations may be less likely to be corrected in adults than in children, given social norms concerning polite conversation. In this way, the hypothesis that perceptual impairments negatively affect the quality of individual semantic representations can be reasonably extended to adults, as investigated in the present study.

No research with NLD participants was found that directly addressed this hypothesis. In my Master's study of reading comprehension, weaknesses in perceptual organization were related to low scores for an untimed test of reading comprehension in adults with NLD (Stothers & Klein, 2010). Problems with arranging blocks into patterns, and with fitting unlike visual stimuli together to create a whole, were seen as indicators of underlying weaknesses with the integration and organization of mental representations. This difficulty in turn was interpreted as a source of weaker ability to structure representations of text, leading to impaired comprehension. Extending the interpretation here, the possibility that weaknesses in perceptual reasoning may also affect language at the level of single words was considered. Although standardized scores for tests of word knowledge may not be significantly different between adults with and without perceptual reasoning impairments, the study described in the previous chapter found that these scores do not capture information about all aspects of word knowledge. Most pertinent to the present study is that most standardized vocabulary tests do not adequately measure depth of semantic representations.

The approach to quantifying depth described next was based in clinical experiences, as well as the hypothesis that disrupted perceptual experience in NLD affects semantic representation. First, a short homograph task was used to test the impression that students with NLD had fewer semantic associations than their peers, as illustrated by the following clinical example. A young adult student with NLD was frustrated academically and in her daily life by a sense that she could not generate words as successfully as her peers. This student had average vocabulary but reported struggling in her courses. We used a simple word association exercise to examine the problem and practise making associations. When asked to make as many associations as she could to the word *red*, on her first attempt the student generated four in total. Readers should try this exercise themselves to appreciate how few associations she produced. Red rose, redneck, red carpet, fire engine red, red ribbon, red alert, seeing red, cardinal red, red letter, red herring, in the red, red rover, fire, love, anger, embarrassment, and stop signs, are all red-related ideas that come to mind fairly quickly. Of course there are many others, and associations will vary by age, culture, and geography. This type of generative difficulty was common in the students, who also reported frequent use of a thesaurus when writing, and having word finding difficulties in social situations. These experiences suggested that a sample of individuals with NLD might be less able to articulate subordinate meanings for common words than would a comparison group without developmental disorders.

Students with NLD also tended to misinterpret polysemous words and make subtle errors in their use of familiar phrases, suggesting a reliance on memory for word definitions that were either learned incorrectly, or were not updated for use in context. Some of these phrases had personal or individual meanings into which multiple experiences had been distilled without apparent memory of their origins[5], or had been learned as a unit; either way, without updating, over time such definitions became limited in their scope and acted

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[5] For example, a student with NLD described her difficulties integrating environmental, social, cognitive, and emotional information in the moment as her *delayed response*. She used this phrase repeatedly, and over time the phrase signified any negative social interaction she experienced, becoming a collocation for complicated but dissimilar inter-personal dynamics.

as collocations. As discussed in the previous chapter, collocations are a type of formulaic language consisting of pre-learned, predictable combinations of words that are retrieved as wholes from long-term memory (Molinaro & Carreiras, 2010). In the past, idiomatic collocations were characterized as semantically empty. Although more recent research indicates that this is not necessarily the case, recognition of the word string appears to happen before meaning is accessed (Molinaro, Canal, Vespignani, Pesciarelli, & Cacciari, 2013), suggesting that collocations may be used in familiar contexts with varying degrees of awareness or intent. The characterization by some of language use in NLD as empty (Johnson & Myklebust, 1967; Rourke & Tsatsanis, 1996) may be one end of a continuum of individual differences in the use of formulaic language (Lev-Ari & Keysar, 2014; Vulchanova, Saldana, Chahboun, & Vulchanov, 2015), in which communication is diminished rather than enhanced by repeated uses of conventional phrases. The use of collocations without precise or adequate semantic representations may not be immediately apparent in the context of typical vocabularies and average or better academic achievement (see Davis & Broitman, 2011; Mamen, 2007; Palombo, 2006; Thompson, 1995 for clinical consideration of this issue). Thus, a comparison of the frequency of their occurrence in adults without learning disorders and those with NLD was made here.

Another type of inflexibility that was seen in my clinical experience occurred when students with NLD had difficulty with matching *word-stress homographs* to the contexts in which they appeared. Word stress homographs are words for which meaning depends on which syllable is stressed more heavily (Small, Simon, & Goldberg, 1988), for example: *The artist was known to appropriate comic strips in her paintings*, versus *The artist was happy to accept an appropriate offer for her comic strip paintings*. In practice, it was not clear whether the difficulty was related to (a) word pronunciations that had been learned and stored incorrectly, (b) never having heard words spoken aloud, (c) having connected different pronunciations of the same word to different spellings, (d) difficulty accessing familiar and less familiar pronunciations, or (e) problems accessing and integrating less common meanings in context. Although individuals with NLD are said to have difficulty with prosody in general (Gross-Tsur et al., 1995; Ris et al., 2007; Rourke, Del Dotto, Rourke, & Casey, 1990), word-stress differences have not been tested

in NLD as either a source of reduced semantic depth, or as part of an evaluation of the hypothesis that prosodic features such as pitch, duration, or rhythm are impaired. An exploratory, single word item examined word stress in this study.

Returning to a more direct role of perceptual difficulties in NLD, Myklebust (1975) described the effect of these differences as distorting "the meaning of experience itself" (p.85), asserting that "[t]he meaning of verbal concepts is derived from nonverbal experience" (p.100). Children with NLD in Myklebust's case studies struggled with estimating time, distance, weight, and other quantities (see also Gross-Tsur et al., 1995; Mamen, 2007; Moss Thompson, 1985; Semrud-Clikeman & Hynd, 1990). In the word knowledge study reported in the previous chapter, some adults with NLD also had difficulty with articulating their understanding of material or physical things, suggesting the lasting influence of perceptual weaknesses on vocabulary. For example, more than one participant with NLD had difficulty describing a sphere, and errors for word definitions that involved shape, quantity, and direction were observed. These findings were in line with research in which children with NLD had difficulty making inferences based on spatial premises (e.g., the cat is behind the chair), but not other, non-spatial statements (e.g., the cat has black fur; Worling et al., 1999). The present study included a verbal measure of cognitive estimation that required distinct representations of how words are related to size, weight, and other material qualities. The ability to combine lexical and affordance knowledge to estimate amounts was used to operationalize the potential link between perceptual experiences and semantic representations.

4.1   Research Questions and Hypotheses

In summary, the proposal that the depth of semantic representations is reduced as a consequence of nonverbal gestalt perception weaknesses was explored by examining word definition abilities in participants with NLD and in those without. Results for a single meaning Vocabulary test and a multiple meaning Homographs test were compared with a verbal test of the ability to estimate size, distance, time and weight, as well as tests of nonverbal perceptual organization. The following hypotheses were tested:

1. Adults with NLD have less rich semantic representations than do adults without NLD, evidenced by (a) reduced ability to articulate multiple meanings for polysemous words, (b) an increased use of imprecise collocations, and (c) a failure to identify different meanings for two pronunciations of the same printed word that depend on word stress.

2. Scores for Homographs (polysemous word definitions) are predicted as well or better by Gestalt Closure, the nonverbal test of gestalt perception, and Estimation than by Vocabulary (non-polysemous word definitions), despite the common demand for word definitions that these tests share.

4.2 Method

4.2.1 Participants

Participants were 50 adults (30 females) between 18 and 52 years of age who had finished secondary school, and had completed or were engaged in some form of post-secondary training or education. The participants' education ranged from one term of college courses to completed Master's degrees. Some of the adults ($n = 30$; NLD group = 16, Control group = 14) completed the tasks as part of my Master's research, but the Homographs and Estimation data were not included in the thesis (Stothers, 2005). Additional participants ($n = 20$; NLD group = 11, Control group = 9) were recruited from the same college and university sources and through word of mouth. Participants in the group with NLD ($n = 27$) had a community diagnosis of NLD. They also had to report accommodation use in elementary, secondary, or post-secondary school, or a history of employment accommodation. Participants in the Control group ($n = 23$) reported never having used accommodation or services for a disability at school or work, or having undergone an assessment for a possible learning disability or ADHD.

Exclusion criteria for both groups were sensory impairments, brain injury, or medical conditions such as seizure disorder. Participants whose first language was not English were also excluded. There were three participants with an additional diagnosis of ADHD in the NLD group, and four others who had a history of clinical depression. No other

psychiatric conditions were reported. None of these participants were taking stimulant or anti-depressant medications at the time that data were collected. The majority of the sample was Caucasian.

4.2.2   Materials

The participants completed five measures. Three of these were part of the battery of tests used in the previous study: Vocabulary, Block Design (Wechsler, 1997), and Gestalt Closure (Kaufman & Kaufman, 1994). The other measures were (a) Homographs, a five item test of the depth of semantic representations, and (b) Estimation, a verbal test of the ability to quantify physical characteristics of everyday objects. Both of these were experimental tasks (described in further detail below), and no reliability data were available. Vocabulary was used to measure the ability to define single meaning words, that is, as an estimate of breadth of word knowledge (Corrigan, 2008), against which potential differences in depth of semantic representations could be compared[6]. Block Design was used to corroborate community diagnoses of NLD, as the test has been used as a marker of prototypical weaknesses associated with the disorder (Pelletier et al., 2001; Mammarella & Cornoldi, 2014). The Vocabulary and Block Design subtests from the third edition of the Wechsler Adult Intelligence Scale (WAIS III; Wechsler, 1997) were administered to the original 30 participants. In the more recent data collection these same two subtests were drawn from the WASI. Correlations between Vocabulary and Block Design across these two Wechsler batteries have been reported as .88 and .83, respectively (WASI, 1999). The last measure, Gestalt Closure, was used to estimate gestalt perception, as described in the previous study. In this administration, whether or not participants completed the test in less than 10 seconds was not recorded.

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[6] Some of the items in this version of Vocabulary were polysemous, as they could be defined either as nouns or verbs (e.g., *visit*). However, only one meaning is required in this administration, and providing both meanings did not result in additional points; therefore, the test was considered to be a measure of single word meanings.

4.2.2.1   Homographs

Participants read five homographs, that is, words that have more than one meaning but for which spelling does not vary[7], and were asked to generate as many different meanings for each word as they could. Items were the same as those used in my Master's thesis (Stothers, 2005), as noted, and no time limit was imposed. The first dependent variable for Homographs was the number of meanings produced in response to *fair, bank, diamond, object,* and *point* (see Appendix B). Overall, it was expected that participants with NLD would generate fewer meanings than the Control group. The second outcome was collocation frequency. A collocation was coded when a formulaic phrase was used without a clear explanation of its meaning. For example, if participants said *diamond in the rough* or *fair-weather friend* without then providing an explanation of what the phrase meant, this response was counted as a collocation. It was expected that the NLD group would produce more incorrect collocations than would controls. The third outcome depended on the word-stress Homograph item, *object*, which was included as an initial exploration of whether difficulties with word-stress may also limit depth of semantic representations. Based on clinical experience, the NLD group was expected to be less likely to find meanings for both pronunciations, *ob*ject (thing, goal, or a part of speech) and ob*ject* (to disagree).

4.2.2.2   Estimation

Participants were asked to estimate size, length, distance, weight, and other measurements in combination with another judgment, where estimation is the process of arriving at an unknown amount by combining available data (Bisbing et al., 2015;

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[7] In other research, homographs have been distinguished from polysemous words. Distinctions have been made between definitions that are entirely distinct, e.g., carnival versus equitable for fair, and definitions that are related but different, e.g., the association between light in colour and beautiful, also for fair, with the first example being strictly homographic and the second polysemous. In discourse, mutually exclusive definitions require selection of one meaning and suppression of alternatives, whereas in polysemous definition tasks, activation of one meaning may support the retrieval of a similar meaning (Ari-Lev & Beysar, 2014). Because both types of response were encouraged in the instructions and demonstration item, homographs and polysemous words were used interchangeably in describing and discussing the results.

Wagner, MacPherson, Parente, & Trentini, 2011). The test was chosen as a measure of perceptual reasoning in a verbal format. For example, "How long is the average metered parking space downtown?" requires relating size to affordance data, combining imagery or knowledge about the size of an average car with experience of how much space is required to manoeuvre a car between two others. The total score was the number of items for which participants provided an answer within a range established in advance as a reasonable approximation of the exact amount. Participants could use either metric or imperial units. Eight items were taken from a study of children with cognitive impairment secondary to prenatal alcohol exposure (Kopera-Frye, Dehaene, & Streissguth, 1996), with two items from Shallice and Evans (1978) and an additional five items devised by the researcher (Appendix C). Control ranges for all items were calculated by adding or subtracting a percentage of actual amounts, creating a range of reasonable amounts. This procedure gave similar control ranges to those provided by Kopera-Frye et al. (1996), but was applied to all items for consistency (Della Sala, MacPherson, Phillips, Sacco, & Spinnler, 2004). The NLD group was expected to have lower scores for this measure as well, given the well-established finding of visual-perceptual and quantitative reasoning difficulties in NLD (Cornoldi et al., 2003; Forrest, 2004; Hendrikson et al., 2007; Mammarella et al., 2009; Mammarella & Pazzaglia, 2010; Rourke, 2000) and Myklebust's observations of similar difficulties in his case studies (1975).

4.2.3   Analyses

The first hypothesis, that adults with NLD have more shallow semantic representations than do adults without diagnoses, was addressed using independent samples *t* tests to compare potential group mean differences in total scores for Vocabulary and Homographs. For the latter variable, collocation frequency and identification of the word-stress item were also analyzed. The number of times that collocations without accurate or full explanations of their meaning occurred in each group was counted, and errors were reported. Collocations were noted in the original data collection, but audio recordings that would have allowed a determination of whether formulaic phrases were used correctly were not made. For this reason, collocation performance was analyzed for

20 participants, 12 with NLD and 8 in the Control group. A Fisher's exact *t* was used for both the collocation counts and the word-stress item. No differences between adults with NLD and controls were expected for Vocabulary. Mean scores for the number of meanings produced for Homographs were expected to be lower for the NLD group. More frequent use of collocations and less frequent identification of a word-stress homograph were also expected for participants with NLD in comparison with the controls. Lower scores were expected for NLD participants on two measures of perceptual reasoning, and for estimates of physical qualities such as speed and distance.

For the second hypothesis, that perceptual reasoning contributes as much to knowledge of polysemy as does knowledge of generally non-polysemous words, regression analyses examined the contribution of group and predictor variables to scores for Homographs and for Vocabulary separately. Two-tailed correlations were run first to confirm linear relationships between variables for the regression analyses. The null hypothesis was based on the assumption that if the same cognitive processes were underlying both measures, regression analysis models would not be different. Instead, it was expected that Homographs scores would be significantly predicted by the perceptual organizational measures, but that these variables would not contribute to a model for Vocabulary. Similarly, it was expected that group status would significantly predict Homographs scores, but not those for Vocabulary, if the two groups had equivalent word knowledge but differed in the depth of their semantic representations.

The number of terms of post-secondary training that each participant had completed was also recorded and included as an Education variable in these analyses. Increases in years of education have been found to increase scores for tests of verbal IQ (see Salthouse, 2004, for discussion of this effect, in which cross-sectional designs like the current study cannot disentangle the influence of these variables from each other). However, it was unknown whether Education would affect depth of semantic representation equivalently, or at all, across the sample or differentially by group. As well, an implication of the hypothesis that perceptual impairments limit depth of semantic representations would be that the NLD group would benefit less than the Control group from the linguistic

experiences associated with education. The years of Education variable was included in the regression analyses for these reasons.

To summarize the predictions, it was expected that the NLD group would have significantly lower mean scores than the Control group for Homographs and Estimation, but mean group differences were not expected for Vocabulary. Significant group differences were expected for Block Design, supporting the community diagnoses for participants in the NLD group. More frequent instances of collocation use and less frequent identification of two meanings for the word-stress Homograph item were also predicted for the NLD group. Both of the perceptual organization measures were expected to differentiate between groups, given that one criterion on which participants with NLD were diagnosed as having the disorder was a weakness in perceptual reasoning. Different variables were expected to contribute to score variability in Vocabulary and Homographs for the whole sample, and Education was expected to be more strongly correlated with Homographs in the Control than the NLD group.

4.3   Results

All variables were normally distributed, with skewness and kurtosis values within plus or minus two (Hair & Black, 2000) and without outlying scores, so no transformations were necessary prior to data analysis.

4.3.1   Question 1: Group Differences in Depth of Semantic Representations

The Control group had significantly higher Homographs scores ($M = 15.73$) than the NLD group ($M = 11.26$), $t(48) = 7.31$, $p < .001$ (Table 4-1; Figure 4-1). For Block Design, diagnoses of NLD were supported by a significant mean group difference, $t(48) = 9.21$, $p < .001$. Similar statistical differences were seen for all other variables, including an unexpected group difference in Vocabulary, $t(48) = 2.94$, $p < .01$. Consequently, Vocabulary was used as a covariate in a univariate analysis of Homographs scores, with significant group differences emerging for the corrected model, $F(2, 48) = 35.41$, $p < .001$. Estimated marginal means for Homographs were = 15.43 for

Table 4-1: **Dependent and predictor variable group mean comparisons and descriptive statistics by group**

Variable	Comparison	Group	
	t (mean diff.), CI (l, u) p	Control M (SD)	NLD M (SD)
Vocabulary	2.94 (2.28), (.72, 3.83) $p < .01$	14.61 (2.43)	12.33 (2.96)
Homographs (# of meanings)	7.31 (4.57), (3.31, 5.82) $p < .001$	15.83 (2.08)	11.26 (2.30)
Homographs (collocation)*	-- $p < .003$	1	9
Homographs (word stress)*	-- $p < .01$	2	14
Gestalt Closure	7.60 (5.13), (3.78, 6.49) $p < .001$	12.65 (2.59)	7.52 (2.19)
Block Design	9.21 (4.32), (3.38, 5.26) $p < .001$	12.65 (1.70)	8.33 (1.62)
Estimation	5.76 (7.08), (4.61, 9.55) $p < .001$	23.51 (3.79)	16.44 (4.74)
Years of Education	2.35 (1.03), (.15, 1.90) $p < .023$	3.80 (1.42)	2.78 (1.63)

Note. $df = 48$; CI (l, u) = 95th%ile Confidence Interval (lower, upper). * Scores are number of participants making each type of error by group, with probabilities for Fisher's exact t-test.
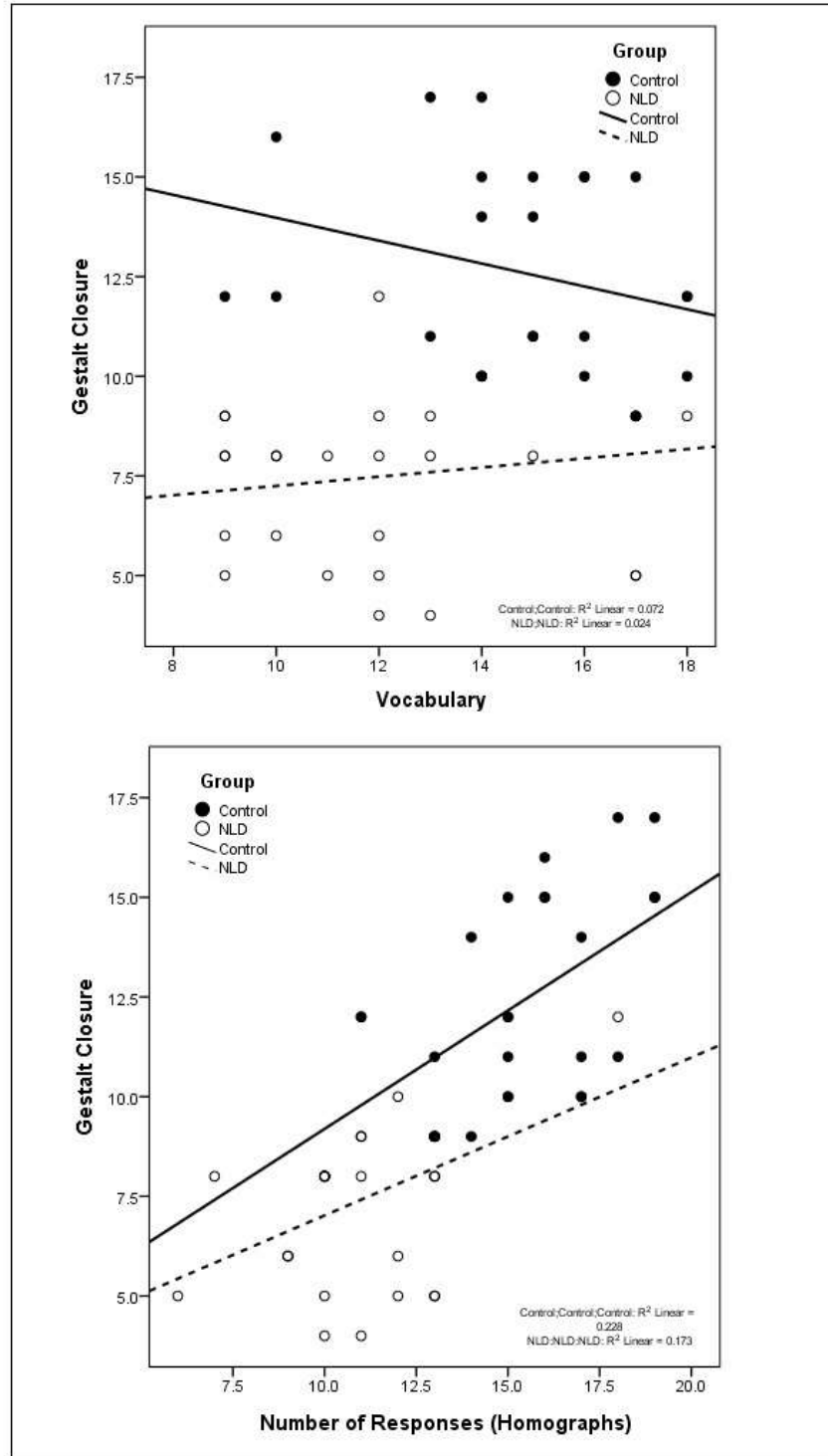
Figure 4-1: Contrasting linear relationships for gestalt closure and word definition measures by group

controls (95% CI = 14.54 – 16.33) and 11.59 (95% CI = 10.77 – 12.42) for the NLD group, demonstrating non-overlapping confidence intervals for the Homograph scores without the influence of Vocabulary. However, because the two groups could not be randomly assigned and differed from each other on all variables, removing the influence of Vocabulary would not be expected to alter the difference in Homographs between groups. This caveat to analysis of covariance is called *specification error* (Miller & Chapman, 2001).

Consequently, two alternatives were considered to further explore the impact of the group difference in Vocabulary scores. In one, following Mervis et al. (2005), participants with the highest scores for Vocabulary were removed from analysis one-by-one until the null hypothesis, namely that groups were not different on Vocabulary, could be clearly rejected. With the top five vocabulary scores in the Control group participants (two of whom had scaled scores of 18 and two with scores of 17) eliminated from the sample, the groups did not differ, t (43) = 1.85, $p < .1$ for Vocabulary. Without these participants, the statistically significant mean difference between groups was removed for Vocabulary but not for Homographs, t (43) = 7.06, $p < .001$. In the second alternative, a numerical estimate of the influence on Homograph scores of Vocabulary and group independent of each other was obtained via regression analysis. This was also a planned analysis to contrast the influence of perceptual organizational variables on the verbal outcome measures, as described below. A difference in years of Education in favour of the Control group was also statistically significant, t (48) = 2.35, $p < .02$; however, entering Education as a covariate into a multivariate analysis did not alter the pattern of significant group differences for any of the dependent variables. There was no group difference for the age of the participants.

4.3.1.1   Collocations

As noted previously, collocation results are reported for 20 participants whose responses to Homographs were recorded. The Fisher's exact t test for collocation errors was significant, $p < .003$, with errors made more frequently by members of the clinical group. Nine of 12 participants with NLD demonstrated errors in the semantic representations

they had for familiar words and phrases. In total, there were 26 instances of errors in these 9 participants. One of the 8 control participants made a single collocation error, defining *fair-haired* as *having fine or weak hair*. In the NLD group, collocation errors such as the following were made: A participant who provided the term *fair weather* elaborated on his definition by saying *it looks cloudy out*. To *bank on something* was explained as being *a high validity source or promise on someone, a word of reliability.* Control participants were able to explain *to bank time* as holding it back to save for a later time, or to take a *bank shot* as hitting a ball off the side of a barrier. A participant in the NLD group generated *to bank to the left*, but could not find another word for *bank* to explain his response. Only one participant with NLD was able to correctly elaborate on an attempt to describe a *bank shot*. *Diamond in the rough* was used by participants in both groups, but participants with NLD did not explain the phrase in a typical way. One defined it as something that looks more beautiful because of its ugly surroundings. Another said that the phrase meant that a person is valuable or someone with worth, but could not articulate the conjoined meaning of the person needing polish or refinement.

4.3.1.2 Word-Stress

A Fisher's exact test for overt identification of the word-stress homograph also was significant, $p < .01$ in the expected direction. Two of the 23 member Control group did not find meanings for both *ob*ject and ob*ject*, in comparison to 14 of 27 participants with NLD.

4.3.2 Question 2: Statistical Contributions to Vocabulary and Homographs Scores

On regression analyses, models for Homographs and Vocabulary were not interchangeable (Table 4-2). For Homographs, $R^2 = .71$, such that 71% of the total variation in Homographs could be explained by the predictor variables. The covariate, Vocabulary, was entered first, removing the variance that the group and the covariate shared, leaving the residual effect of group that was not related to Vocabulary. Then group was entered, producing a statistic for the correlation between group and Homographs, without the statistical influence of Vocabulary. The other predictor

variables, Gestalt Closure, Estimation, and Education, were entered next. Group status accounted for approximately 3.7% ($r = .192$) of the variability in Homographs scores for the sample, Gestalt Closure for 9.5% ($r = .309$) and Vocabulary for 7.2% ($r = .269$). Neither Education nor Estimation explained independent variance in Homographs. In contrast, variance accounted for by the same predictor variables in the model for Vocabulary was lower, $R^2 = .45$, and there were no effects for group, Gestalt Closure, Estimation, or years of Education. Only the number of meanings produced for Homographs, the other word definition task, made a statistically significant contribution to variance in Vocabulary, accounting for approximately 14% ($r = .371$) of the variance in scores.

Table 4-2: Goodness of fit statistics for regression analyses

	Vocabulary		Homographs
	β, t, p		β, t, p
Homographs	.60, 3.31, $p < .002$	Vocabulary	.34, 3.31, $p < .002$
Group	-0.07, - .35, n.s.	Group	.34, 2.36, $p < .05$
Gestalt Closure	-0.29, -1.57, n.s.	Gestalt Closure	.44, 3.52, $p < .001$
Estimation	.25, 1.81, n.s.	Estimation	-.13, - 1.16, n.s.
Education	.24, 1.96, n.s.	Education	.03, .30, n.s.
Model	$R = .68$, R^2 adj = .39, $F = 7.21$, $p < .001$	Model	$R = .84$, R^2 adj = .70, $F = 19.75$, $p < .001$

Note. Education = years of post-secondary education completed at the time of data collection. β = beta weight

As noted, a correlational analysis checked that items were linearly related, and this was confirmed. The statistical relationship between years of Education and Homographs was more positive for the Control group than the NLD group, an analysis conducted in part to explore whether the usual influence of education on Vocabulary scores was also present for Homographs scores, in the entire sample, and by group (Table 4-3). Statistical differences by group were seen, with the expected positive relationship between

Vocabulary and years of Education found only in the Control group, but not the group
with NLD (Figure 4-1).

Table 4-3: Correlations between predictor and dependent variables by group

Variable	NLD group (top rows), Control group (bottom rows)					
	1	2	3	4	5	6
1. Vocabulary	1	.60**	.16	.41*	.04	.26
2. Homographs	.09	1	.42*	-.02	.19	.11
3. Gestalt Closure	-.28	.50*	1	.13	.42*	.07
4. Estimation	.00	-.04	-.08	1	-.02	.10
5. Block Design	.21	.36	.46*	.29	1	.13
6. Education	.57**	.37	.07	.37	.47*	1

Note. Vocabulary, Gestalt Closure, and Block Design correlations were calculated on scaled scores, with a
mean of 10 and a standard deviation of 3. Degrees of freedom for Control group = 22; for NLD group = 26.
* p < .05 (two-tailed test), ** p < .01 (two-tailed test)

4.4   Discussion

4.4.1   Vocabulary Breadth, Vocabulary Depth, and Gestalt Perception

The hypothesis that semantic representations in individuals with NLD lack depth, despite
average or better vocabulary breadth, was supported. The mean score for Homographs
was significantly lower for the NLD than the Control group. Together with results from
the study reported in the previous chapter, the findings suggested that the struggle with
semantic integration in adult students with NLD with whom I worked was measurable,
and was related to difficulties with nonverbal gestalt perception and formation of a novel
whole: The participants with NLD had difficulty with Object Assembly and Gestalt
Closure, in comparison with controls. The latter nonverbal measures were hypothesized
to rely on the same integrative abilities that in the present study were measured by
Homographs, as discussed next.

In theory, a facility with Homographs relies on the ongoing formation of gestalts; adding multiple meanings to representations of polysemous words requires updating and storing meaning when new uses are encountered[8] (Corrigan, 2008). This interpretation was supported by regression analysis results. The model for Homographs that included Gestalt Closure explained 71% of the variance in scores. In contrast, Gestalt Closure did not contribute to the linear regression model for Vocabulary scores, and the same predictors explained less total variance across the sample.

Once the semantic representation for a non-polysemous word has become familiar and well-learned, however, it is proposed that gestalt processes in maintaining semantic representations are diminished. Here, such a shift emerged in correlations between variables in the Control group, but not in the group with NLD. The shift for the Control groups is illustrated in Figure 4-1 by the change in the slopes for correlations between Gestalt Closure and Vocabulary, and Gestalt Closure and Homographs. The former relationship is negative, and the latter is positive and larger, suggesting that gestalt perception contributes more to polysemous than non-polysemous representations in well-educated, typical adults. This relationship between Homographs and Gestalt Closure is consistent with the view that the acquisition of vocabulary, and its deepening, occurs over a lifetime (Andrews, 2011; Corrigan, 2008).

The same pattern was not seen in the NLD group. Slopes for the statistical relationship between Gestalt Closure and the two word definition tasks were both positive (Figure 4-1), suggesting that the influence of gestalt perception is not lessened over time to the same degree; that is, strategies for vocabulary acquisition may not change as they appear to in typical adults. Instead, word learning in individuals with NLD may rely more on memorization, regardless of age, in part because of the weaknesses in gestalt perception

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[8] To illustrate, the practice item given for the Homograph test was *down*, a word for which a new meaning has emerged in recent slang. Down may refer to a direction, a sad mood, a feather lining in a coat or blanket, and more recently, being *alright* or *in agreement with* a suggestion, as in the collocation *I'm down with that*. Adding the last meaning for down requires that a listener consider that none of the familiar and easily accessed meanings are suitable, and then recall its use in other contexts. Listeners must integrate context, tone, and intention to produce a new interpretation, or a gestalt.

that were seen here. Word learning in the adults I met in my clinical experience shared features described in adults who are second language learners. According to Schmitt (2012), in native language learners, and in typical development, meanings for formulaic phrases are learned and stored as units, but that semantic representations for each word in a phrase are also stored separately. However, in second language acquisition, words and phrases are said to be memorized in chunks that are less integrated with context, and may not be completely understood (Borovsky et al., 2012; Schmitt, 2012; Wang & Shih, 2011). Word learning in children with ASD has been similarly described (Dobbinson et al., 2006; Vulchanova et al., 2012). Dobbinson et al. (2006) use gestalt to mean formulaic language, learned as connected wholes, in contrast with analytic or generative language, in which each term has a separable meaning that contributes to a phrase. Although the meanings of these terms are reversed in the present work, the shared argument is that gestalt and analytic approaches to language learning are balanced in typical development (Schmitt, 2012), but may be less so in NLD and ASD. Whether such differences may be seen developmentally could not be evaluated in a cross-sectional study with an adult sample (Karmiloff-Smith, 1998). A longitudinal study of this proposal is suggested.

The hypothesis that perceptual organization affects depth of semantic representations assumes that integration is a fundamental cognitive process that results in novel concepts independent of test stimuli format (Coulson, 2006; Fauconnier & Turner, 1998), but does not overlook the fact that cognition involves both analytic and holistic approaches that work in concert (Dien, 2009). Individuals with NLD are not incapable of gestalt perception or semantic integration, but the present results support clinical assertions that they make novel links between unlike parts less frequently or easily (Grodzinsky et al., 2010; Harnadek & Rourke, 1994; Mamen, 2007).

Differences between groups in correlation patterns for Vocabulary as they were related to Education also supported the interpretation that language acquisition is atypical in adults with NLD. As expected, scores for Vocabulary and Education were significantly and positively correlated in the Control group; formal education is related to an increase in the breadth of vocabulary (Salthouse, 2004). In the NLD group, however, correlations

for Education and the other variables ranged from almost zero to a small, and not statistically significant, correlation between Education and Vocabulary. This lack of relationship suggested that vocabulary development in individuals with NLD benefits less from education than in their peers without learning disabilities, consistent with a general supposition in learning disabilities research known as a Matthew effect (Vellutino et al., 2004). Because the NLD group had average breadth of vocabulary, again it seemed that they may have relied on memory for representations that were sometimes accurate (*ersatz* is a synonym for *fake*), and sometimes not (to *exercise caution* for *rash*). The influence of long-term memory will be discussed in the last chapter, but for now it is noted that the interpretation of results here can account for normal breadth and reduced depth of vocabulary, as well as unusual semantic representations that occasionally emerge.

As noted in Results, the significant difference in group mean scores was also found for Vocabulary, raising the question of whether the difference in Homographs was simply driven by a difference in Vocabulary. This appeared not to be the case, however. The Control group had a very high scaled score mean of almost 15, or the superior range of function (Table 4-1)[5]. The mean NLD group score was at the high end of the average range, or 12, and consequently could not be considered to be impaired. As well, there was no difference between a similar sample of NLD adults and controls for any of three tests of word knowledge in the earlier study reported here. At a minimum this suggested that limited word knowledge is unlikely a meaningful difference between Control and NLD groups in general, at least in adults with post-secondary education (Stothers & Klein, 2010; Stothers & Oram Cardy, 2012). As well, the technique for rejecting the null hypothesis that the groups did not differ in Vocabulary (Mervis et al., 2005) did not affect the statistically significant group differences seen for Homographs. Future studies could include other comparison groups whose word knowledge would be expected to be lower than those with NLD to further clarify this issue[9].

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[9] Data were available for adults with dyslexia (n = 13) but were not included because phonological impairments could not be ruled out for the participants in Chapter 2 whose data was added. It is of interest, however, that these adults had scaled scores for Vocabulary that were comparable (M = 10.92) to the present NLD group (M = 12.33), but that their mean Homographs score was 14.08, closer to the Control

4.4.2 Semantic Depth, Collocations, and Word-Stress

4.4.2.1 Collocations

Native English speakers have been noted to use collocations in their verbal expression frequently, with estimates of as high as 30 percent of everyday conversation (Schmitt, 2012). On this basis, it may have seemed that looking for differences in collocation use between the Control and NLD groups was overly subtle, or formulaically, an exercise in splitting hairs. However, only the use of collocations for which participants had incomplete or inaccurate representations was tallied. As noted, one of the control participants made a collocational error. This participant also did not define object as a verb. The participant did not report having a developmental disorder, and no further information was available. In contrast, there were multiple errors in defining familiar collocations in the NLD group, a phenomenon that has been described in people learning a second language (Schmitt, 2012; Wang & Shih, 2011), and in developmental disabilities (Tew, 1979). Here, these instances of ill-defined collocations were contrasted with more typical formulaic language, which has been described as efficient and essential (Schmitt, 2012).

Collocations are used to communicate complex ideas quickly (e.g., climate change; the medium is the message); to communicate social intentions (e.g., all the best; I'll let you go now) and shared cultural experiences (go ahead, make my day; God save the queen); to complete extremely familiar and routine interactions with others (e.g., I'll see you later; I'll have a double-double); to signal changes in the direction and valence of an argument (e.g., on the other hand, on a happier note), and other communicative functions (Biber, 2009; Schmitt, 2012). Consequently, there are pragmatic implications of errors in collocation use (Corrigan, 2008), in which information that is sent may not be understood as intended, either in full or in part. A misconstrual of *fair weather* to mean a *cloudy* day

than NLD group mean here. The group of adults with dyslexia also had average to above average scaled scores for Block Design and Gestalt Closure.

would only be apparent in the context of a shared experience of the current weather. This example points to the potentially causal relationship between under-constituted semantic representations and pragmatic difficulties. This relationship could be investigated empirically using measures of both vocabulary and pragmatics, as compared with social reciprocity measures such as the ones used in the first study here. The result also suggests that adults with NLD would benefit, socially, from instruction in polysemous vocabulary.

It could be argued that this finding was not novel. The term *cocktail party syndrome* (CPS) has been used to describe language in children with NLD (Rourke, Ahmad, Collins, Hayman-Abello, Hayman-Abello, & Warriner, 2002; Rourke, del Dotto, & Rourke, 1990; also cited in Clark, 2002; Davis & Broitman, 2011; Lajiness-O'Neill & Beaulieu, 2002; Rissman, 2006; Scheeringa, 2001), but has not been fully described in these studies. The term CPS seems to have originated in studies of language in children with spina bifida and hydrocephalus, congenital conditions involving cleavages in the developing spinal cord and excessive fluid on the brain's ventricles (Culatta & Young, 1992; Tew, 1979)[10]. CPS has been defined as including "the use of many clichés and quotes, phrases out of context, and words without appropriate referents" (Horn, Lorch, Lorch, & Culatta, 1985, p. 713). Other descriptions have included fluent but tangential and irrelevant speech (Culatta & Young, 1992); the exchange of verbal patterns instead of conversations and the use of abstract terms without comprehension (Culatta & Young, 1992; Tew, 1979); grammatically correct utterances and better verbal than performance IQ in children with CPS (Horn et al., 1985).

Some of these features were seen in adults with NLD in the second study; in particular, higher verbal IQ than Block Design scaled scores, and the finding that collocations (clichés and quotes, stereotypic language) without adequate semantic representations (using words without comprehension) were more common in NLD than in controls. Therefore, the overall pattern of formulaic but fluent speech in which a speaker has (a)

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[10] Spina bifida with hydrocephalus is also one of the medical syndromes hypothesized to be a cause of NLD (Rissman, 2011; Rourke, 1995).

inadequate semantic representations of his or her own words, and (b) weaker perceptual reasoning, was descriptively apt for the present sample. However, research with children for whom the syndrome was first described has found significantly lower IQ scores than controls without disabilities, and children with spina bifida and hydrocephalus without CPS (Culatta & Young; Horn et al., 1985; Tew, 1979). In the latter study of children with CPS, the group's mean full-scale IQ score was three standard deviations below the standardized mean. As well as a clear mismatch between intellectual abilities of the children in which CPS was described and the current sample, there were no differences in breadth of vocabulary here. Verbal reasoning in the group with NLD was found to be well within the average range in Chapter 3, and not different from the Control group. Learning disabilities are diagnosed when no other explanation for poor academic achievement applies; in most diagnostic systems this includes developmental delay (Harrison & Holmes, 2012; Kavale, Spaulding, & Beam, 2009; Mapou, 2004). Another disparity is that in the early works cited, the presentation of CPS was found to be less severe as children matured, while in NLD it has been asserted that prominent aspects of CPS increase over time (Rourke et al., 2002). The present group of adults made errors occasionally rather than consistently, with numerous instances of unfamiliar words used correctly in context. CPS, therefore, is inaccurate in that it is an overly broad term to use to describe oral language in NLD. Alternative terms such as *incomplete semantic representations* or *collocation without representation* would be more precise, if less memorable, than CPS. Either of these alternatives also would emphasize the contribution of semantic representations to collocation errors, rather than focusing on their use in social situations.

4.4.2.2   Word-stress

Difficulty in accessing both pronunciations of object in the NLD group was as hypothesized, given past clinical experience and the observation that prosody in general is a weakness in NLD. *Object* was chosen as the word-stress item because it has more than one common meaning. Very few participants in either group, however, provided *goal* or *a part of speech* for this item, suggesting that *to disagree* is more familiar than either of the other two definitions. Even though participants were aware that each word

had more than one meaning, half of those in the NLD group could not provide more than one, despite the finding that familiarity assists word retrieval (McNamara, 2005). The item chosen may not have been ideal, as some participants with NLD spontaneously defined objectivity and objective, and found the second pronunciation of object by this route. More than one participant with NLD was uncertain as to whether *ob*ject and ob*ject* share a spelling: Some, but not all, individuals with NLD have difficulty with the grapheme aspect of their mental representations for grapheme to phoneme links that support spelling (Stothers, 2005; Vellutino et al., 2004). All participants provided at least one accurate definition for each word, a second reason to rule out lack of vocabulary breadth, and eliminating a simple inability to read the word. It seemed unlikely that any of the participants with NLD were unfamiliar with ob*ject* as a verb, an assumption that suggested retrieval difficulties as an alternative. It was also apparent that in general people without learning disabilities do not require context to access both pronunciations of the written word. As a one item measure, no conclusions were drawn. Possibilities for the difficulty with the item, including shallow semantic representations, separately stored semantic representations, lack of contextual cues, or some or all of these in combination, could not be differentiated. Instead, it was proposed that researching word stress homographs and other forms of prosody in NLD may hold some promise for delineating diagnostic characteristics, as well as for designing and testing interventions.

4.4.3   Semantic Depth and Estimation

Cognitive estimation tests are thought to rely on executive functions, with the first published use making a link between frontal lobe damage and extremely odd estimates (Shallice & Evans, 1978), and a well-studied link between the frontal lobes and executive functions (Kuperberg, 2007; Powell & Voeller, 2004; Semrud-Clikeman et al., 2014). Replications with neuropsychological, psychiatric, and typical samples have had mixed results, however, finding the involvement of other brain regions, and expanding the neural networks involved in the task, for example to right parietal areas (Bisbing et al., 2015; Harel, Cillessen, Fein, Bullard, & Aviv, 2007; Wagner et al., 2015). Literature in educational and cognitive psychology also provided other sources for studies of estimation, but estimation research in all three fields has been conducted in isolation from

each of the other areas (Hogan & Brezinski, 2003). As such, there are various kinds of estimation tasks that involve differing types of problem-solving. The latter authors used exploratory factor analysis to find statistical relatedness amongst a group of estimation tests, including *numerosity* (the ability to judge and compare arrays of objects that do not have a symbolic label), measurement (what dimensions, what length of time, etc.) and computational estimation (e.g., what is 3.12 x 8.79?), as well as standardized quantitative reasoning and arithmetic tests. A close relationship between numerosity and measurement estimation was suggested to be influenced by spatial ability. Only computational estimation was statistically related to the arithmetic and reasoning tests.

The results here were in line with the view of cognitive estimation as related to spatial skills, including spatial working memory, given that lower scores for Block Design co-occurred with measurement estimation in the NLD group. One of the defining characteristics of NLD is a general weakness in mathematics (Forrest, 2004; Mammarella & Cornoldi, 2014). Lower Estimation scores were expected from this perspective because of a demand for mental mathematics in forming estimates. Further research could disentangle the influences of spatial and executive function abilities, as well as the clarity of numerosity and number line representations, access to mathematical facts, and other factors involved in mathematical learning disabilities (Bartelet et al., 2014) in participants with and without a diagnosis of NLD.

However, scores for Estimation did not contribute to statistical models that predicted scores for either Homographs or Vocabulary. Given that Estimation was a verbal measure of perceptual experience, it was expected that performance on Estimation would also account for scores on Homographs if perceptual experiences influence depth and flexibility of semantic representations. A relationship between Estimation and Homographs may have been too indirect to be visible in a sample of adults, perhaps mediated by crystallized knowledge (Wagner et al., 2015) as much as it was expected to be mediated by perceptual experience. That items were not matched to recent research in cognitive estimation may also have been a factor. This version of Estimation was designed in 2003 (Stothers, 2005), before the studies cited above were available.

Although Estimation scores did not contribute statistically to results for Homographs, a more general relationship to differences in semantic representations was expressed by the content of responses by participants with NLD in comparison with the controls (Appendix C). Some of these responses indicated indistinct representations of amount, most notably in unit errors that controls did not make. For example, some participants with NLD had difficulty finding an appropriate unit in which to express an estimate of the circumference of the largest tree in the world, answering in degrees rather than meters or feet. Three participants with NLD answered in this way, for example, "that's probably a really huge tree, so I will say 700 degrees". They were relating their knowledge that there are 360 degrees in a circle with the fact that circumference is a measurement that encircles an object, and in doing so demonstrating that their representation of each concept was incomplete or unclear. None of the control participants used degrees as a unit of measurement for this item.

In some instances it seemed that participants could not relate knowledge they presumably would have had to the question being asked. This was true of monetary estimates, in which a large number like the University's budget was estimated to be as low as a single faculty member's annual salary, or only one hundred times the annual tuition fee for an undergraduate student at a university in which the student population is approximately 30,000. Errors for these items may have reflected a difficulty with the integration of representations formed for separate experiences.

Errors regarding travel, in which speed had to be united with distance, were inconsistent in their magnitude within and between participants. A flight to the moon was estimated in some cases to take approximately an hour, and the smallest estimate was in milliseconds. It was possible, in the latter instance, that the participant believed that a millisecond is a larger unit of time than a second, but it was unclear why he chose such an unusual measure of time. Such differences between the NLD and control participants may have been related to the errors for the expression of time and time relationships that were seen in the vocabulary study, for example, the reference to time expanding rather than passing, or the confusion about noon versus midnight. There was no pattern to the errors for items that required speed estimates, however – for some participants with NLD,

the time it takes an astronaut to the fly to the moon was estimated as being shorter than the time it would take to swim across a lake. Errors regarding the length of time to run a marathon tended to err on the same side as space travel, or very quickly, ruling out the explanation of human versus machine travel underlying the estimation errors. Difficulties with space and time judgment were also found in NLD case studies. For example, Myklebust (1975) reported that a boy of almost 10 years of age could not cross the road on his own because he had difficulties judging speed and distance, both in isolation and simultaneously.

Overall, Estimation results did not contribute to those for semantic depth, but they were consistent with Myklebust's documentation of confusions in children with NLD about the physical properties of objects and environments (1975). As such the results suggested that Estimation was at the very least a marker of NLD diagnostic status, both by history and by the correspondence between low scores and a community diagnosis.

4.4.4   Theoretical Support

A number of cognitive theories address the connection between weaknesses in perceptual organization and a shallowness of semantic representations, with two being particularly applicable to the current context. The first is the embodied view of cognition, and in particular, of language (Barsalou, 2008; Chwilla, Kolk, & Vissers, 2007; Gibbs, 2013; Wilson, 2002; Zwaan, 2014), and the second is the Bilateral Activation, Integration and Selection model (Jung-Beeman, 2005).

4.4.4.1   Embodied Semantics

 Embodiment holds that cognition is rooted in physical interactions with the environment, and that abstract mental representations are both formed out of, and retain their connections to, lived experiences, perceptions, and actions. A key feature of grounded or embodied cognition is that it opposes the assertion that abstract thought exists *amodally*, or separately from physical perceptions and experiences, in semantic memory (Barsalou, 2008; Casasanto, 2011; Glenberg, 1997; Meteyard et al., 2012; van Dam, van Dijk, Bekkering, & Rueschmeyer, 2012). Wilson (2002) explored embodiment as an update of

the Piagetian view that the maturation of cognitive abilities can be traced throughout sensorimotor development, emphasizing the vital roles of sensory, perceptual, and motor systems in offline reasoning when the physical things to which they refer are temporally or physically removed. Wilson's observation that offline embodied cognition downloads information to these systems from working memory suggests that deficits in perceptual systems that are seen in NLD would have cascading effects, even in the absence of working memory deficits[11].

Piaget's theory was one source for Rourke's contention (1989) that children with NLD have impoverished semantic representations as a consequence of sensorimotor deficits, as outlined at the outset of this chapter. This suggestion was supported even in an adult sample, where differences in semantic depth coincided with perceptual deficits; current theories of embodiment provided a conceptual link. Gibbs (2013) presented a detailed account of the contribution of embodiment to language, in particular metaphor perception. He reviewed brain imaging studies, largely with adults, which found activation in appropriate motor and somatosensory brain regions to the presentation of action and sensory words, either singly or embedded in sentences; this is known as *semantic somatotopy*. For example, known neural correlates of movement of the legs were seen with written presentation of *kicking a ball* and *kicking a habit* in a cortical area known as the pre-motor cortex, using fMRI (Boulenger, Hauk, & Pulvermüller, 2009). Regional patterns of neural activation also distinguished between arm and leg activations for *grasping an idea* and *kicking a habit*, demonstrating a link between perceptual neural systems and their linguistic incarnations that has supported the embodied account of language comprehension (Aziz-Zadeh & Damasio, 2008; Barsalou, 2008), and extending that account to metaphors (Boulenger et al., 2009).

Not all imaging studies have found semantic somatotopy effects for metaphorical language. Aziz-Zadeh and colleagues speculated that an absence of the effect in their

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[11] Working memory tests were not included in this set of studies. Verbal working memory has not been implicated as a weakness in NLD, although visual working memory impairments are common (Mammarella et al., 2010).

research may have been related to the familiarity of metaphors that were used, such as *bite the bullet* or *kick the bucket*, in which over-learned associations may no longer activate motor cortex, but instead be accessed directly as stored linguistic conventions (Aziz-Zadeh & Damasio, 2008). As noted previously, these idiomatic, possibly amodal representations have been termed collocations in other research (Molinaras & Carreiras, 2010). Gibbs also cautioned that the overall question of how well embodied aspects of conceptual metaphor theory account for metaphor comprehension cannot be summarized simply. Experimental results have depended on choice of participants, materials, experimental task, and the ways in which metaphor understanding is operationalized. Similarly, a review by Louwerse and colleagues (Louwerse, Hutchinson, Tillman, & Recchia, 2015) found that the use of perceptually based semantic representations was based in part on individual preferences, as well as experimental contingencies. According to these authors, accessing and manipulating semantic representations has been shown to rely on statistical properties (e.g., how often does this word occur with another), and on underlying modal or embodied relationships. The Symbol Interdependency Hypothesis emphasized the coordination of symbolic with modal perspectives, proposing that the former view holds during quick processing when "good-enough representations" (p. 432) are used, and the latter is necessary for detailed, in-depth understanding. This hypothesis more easily allowed the application of embodiment to the present results. Frequent use of collocations, in concert with shallow semantic representations for polysemous words, supports the interpretation that individuals with lower scores for gestalt perception and Estimation relied more heavily on amodal, or good-enough, representations than did controls, whose scores for these variables indicated no difficulty interacting with and making inferences about the environment.

An observational example illustrated how an embodied perspective would function here. A participant with NLD named *river bank* as a meaning for bank, tracing its shape with her hands, but could not articulate a synonym such as *slope*, or *edge*. This participant felt that she could not find the word that she believed she had stored for this feature. Alternatively, it was possible that the participant had not actually formed a modal semantic representation for river bank, and only had the noun phrase *river bank* in her memory. She may not have connected disparate exposures to the term *slope,* for example

in a mathematics class, or judging the angle of a hill to climb, and thus did not have a full semantic representation of the gradual incline at the edge of a river. In another instance, a participant could not retrieve a synonym for a "point in sports", rejecting his own suggestion of tally and not being able to name others. It was possible that this participant had filed separate meanings for discrete words like *point, score*, *goal*, and *tally.* This suggested another way in which the word knowledge in these participants may vary, in which representations are more definitive or categorical, and less linked than may be typical[1]. In these and other cases, participants believed that they knew the words for which they were searching, but they may have been relying on either impoverished or overly restricted semantic representations. The application of embodied semantics, particularly as described by Louwerse et al. (2015), fits the pattern of quantitative results and qualitative observations in the present work.

4.4.4.2 Bilateral Activation, Integration, and Selection model (BAIS)

A second theory that is applicable here was also developed from research that has investigated neural correlates of language. The BAIS model (Jung-Beeman, 2005) describes lateralized differences in the brain's response to linguistic stimuli (see also Beeman, 1994, 1998; Beeman & Bowden, 2000; Beeman, Bowden, & Gernsbacher, 2000; Beeman, 1998), regardless of the imageability of the input. In the BAIS model, the left hemisphere is hypothesized to briefly activate closely associated representations in response to a stimulus word, and to quickly select the most familiar meaning that allows further processing. Competing meanings are inhibited if they are determined to be irrelevant to the context. To the same stimulus, the right hemisphere activates meanings, features, associations, and shades of meaning more weakly, but for a slightly longer period (Faust & Kahana, 2002; Mason & Just, 2004; Seger et al., 2000; St. George et al., 1999; Weems & Zaidel, 2004). The field of activation in the left hemisphere is characterized as small and focused, containing closely associated representations; thus, the semantic field in this hemisphere is described as fine. A coarse semantic field refers to larger, more diffuse, and weaker activation of semantic representations in the right hemisphere.   The larger size of coarse semantic fields and a weaker but lengthier period

of activation allows for more overlap between semantically distant associations than is made possible by more focused activation in the left hemisphere. Overlap is thought to facilitate the integration of meanings that are less frequently combined; this has been termed summation (Beeman, 1998; Faust & Kahana, 2002). In this way, the BAIS model specifies the contribution of the right hemisphere to language comprehension. Fluent on-line language comprehension relies on efficient word selection, but the addition of coarse to fine semantic coding would provide distant or unfamiliar meanings when the dominant meaning is ill-suited or without context, as in the Homographs task.

As noted in the Introduction, the possibilities of right hemisphere deficits and a corresponding preference for left hemisphere-biased processing were not explored directly in the present research. Although the simplicity of a left versus right divide is appealing, it is an oversimplification of complicated neurological processes that are still not well understood. For example, brain morphology varies greatly between individuals; structures responsible for coordination between left- and right-sided brain regions are just as variable; specific cognitive functions like language are the product of synchronous activation in distributed cortical networks; developmental changes affect lateralization; neural connectivity may change with intervention and experience; and white matter differences affect left as well as right hemisphere functions (Luria, 1973; Pessoa, 2014; Ross, 2010; Welcome & Joanisse, 2014). As well, the present sample was not tested on low-level perceptual measures in comparison with participants with known right hemisphere brain damage.

Even with these caveats, applying the model to the present results does have some descriptive utility. Applying the BAIS model would predict corresponding weaknesses in coarse semantic coding, a prediction that was consistent with the current results, in which participants provided fewer associations to familiar words. The summation feature of coarse semantic coding would be applied as a mechanism for semantic integration, in which both summation and semantic integration are linguistic incarnations of the simultaneous, integrative qualities typically attributed to nonverbal gestalt perception tasks like Gestalt Closure. If both perceptual organizational and coarse semantic coding processes are right hemisphere biased, one would expect that the measures proposed to

reflect these processes would be positively correlated, as was the case in the current results. Thus, BAIS provides a model to support the stronger relationship between Gestalt Closure and Homographs than between Gestalt Closure and Vocabulary. Because the BAIS model avoids dichotomizing, and describes qualitatively different but necessary hemispheric contributions to understanding language, its use in the present context was consistent with significantly different but overlapping scores for Homographs in the Control and NLD groups.

Working from the assumption of left versus right hemisphere deficits has been a common approach to NLD research[12]. Rourke's model of lateralized deficits in NLD (1989), and the observation that semantic representations lacked content in children with NLD, was based in part on a theory of laterality in human cognition proposed by Goldberg and Costa (1981). Of relevance to language, the theory described the left hemisphere as more adept than the right at processing overly familiar symbol systems like the alphabet, particularly when the system is focused on one representational format. Applying this model predicted the pattern of good word learning and reliance on language for problem-solving that has been observed in NLD (Rourke, 1989). Goldberg and Costa outlined a contribution to the development of semantic representations through right hemisphere-biased integrative functions, also ascribed by other authors to the transformation of bodily and sensory experiences into lexical entries (Andrews et al., 2009; Coulson, 2006; Myklebust, 1975). Thus, the hypothesis that individuals with NLD have fewer opportunities to develop multiple associations to single semantic representations corresponds well with Goldberg and Costa's theory, with embodiment theories, and with the BAIS model.

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[12] Describing processes as predominantly or preferentially right or left hemisphere-biased in a group for whom behavioural tests differentiate them from peers, as was the case with the current sample, is not unreasonable *per se*. Lateralized cognitive differences have been supported by a long-standing distinction in neuropsychological research (Caeyenberghs & Leemans, 2014; Whitehouse et al., 2009; Hugdahl & Westerhausen, 2010, for a review). The problem is less that the distinctions are in error, and more that behavioural findings have been over-interpreted in the absence of data that directly address lateralization.

At a descriptive level, embodied semantics and hemisphere-based differences in semantic coding would not be mutually exclusive. Their theoretical functions as applied to the present data would work in concert. Putative right hemisphere deficits in perceptual reasoning, as demonstrated here by lower Block Design and Gestalt Closure scores, would in theory have been present throughout development and had a negative influence on physical exploration of the environment. According to embodied semantics, less exploration would result in less elaborated semantic representations. According to the BAIS model, impoverished representations in turn would provide fewer opportunities for coarse semantic activation, limiting the number of possibilities for selection of discrete meanings and resulting in the generation and selection of fewer meanings for polysemous words. The results here were compatible with both accounts. The application of models developed and supported by neuroscientific research to the results here was speculative, but these proposals are testable in future studies.

4.4.5 Conclusion

The difficulties experienced by participants in this study were both subtle and frustrating. The social and academic consequences of the struggle to use language both precisely and flexibly have been documented. The majority of the participants who had a diagnosis of NLD were successful in their academic and career pursuits, and in their relationships. Nonetheless, each reported negative outcomes in one or more of these domains, and an inability to articulate the source or nature of the mismatch between their own understandings and the way in which language is interpreted by others.

Taken together, the results of the current study suggested the testable hypothesis that relying on long-term memory for immutable word definitions may be both an effective compensation strategy and a source of difficulty. It is plausible that differences in the depth of semantic representations are not as salient in ordinary conversation as are differences in breadth, given the ubiquity of collocational speech (Biber, 2009; Schmitt, 2012) and the subtle or hidden quality of some errors that were made during Homographs definitions. Collocation without representation appeared to be common in this group of participants, as it was in the students with whose experiences led to this study's hypotheses. Lack of research into these questions has been a barrier to the development

of interventions. If replicated, the contrast between Homographs and Vocabulary could be used clinically as a more sensitive measure of impairment than Vocabulary alone. The former test was easily and quickly administered, and the latter test is often used in diagnostic assessment of NLD. Similarly, Estimation may have potential as a method of evaluating perceptual differences in NLD in a verbal format. More generally, the present study is a first step towards quantifying and better understanding semantic differences in adults with NLD.

Chapter 5

5   Potentially Different Routes to a Similar Linguistic Destination

The focus of this final chapter is linking results for the individual studies by highlighting overall patterns for the clinical groups, and proposing connections between findings as a whole. Summaries of the hypotheses in each chapter and a discussion of the degree of support for each make up the initial sections. Subsequently, areas of similarity and difference in the clinical groups are considered, as compared to each other and the Control group, as are implications of examining the data for within-group differences. Results are summarized in terms of their novelty, their convergence with prior work, and their broader implications for ongoing research and clinical intervention with adults who have NLD or ASD. In the concluding section, research possibilities arising from the data and improvements that would need to be made in replicating the studies are addressed.

Case reports, some experimental research, and clinical experience with adults had suggested a number of hypotheses, including: (a) adults with NLD share social impairments with those who have ASD, (b) word knowledge is not below average in NLD or ASD on normed, standardized tests, (c) semantic representation differs subtly in both clinical groups in comparison with typical adults, (d) nonverbal perceptual organization affects the formation of semantic representations in adults with NLD, and (e) weaknesses in both groups in gestalt perception impair semantic integration. These hypotheses were generally supported. Observations and descriptive examples distinguished participants with either NLD or ASD from adults who do not have developmental disorders, and found few differences between the clinical groups. However, quantitative differences between clinical groups appeared for most but not all cognitive tasks. These outcomes suggested different cognitive, and potentially developmental, paths by which these adults arrive at similar destinations in regard to their language strengths and weaknesses. Overall, results made unique contributions to understanding semantic representations in adults with NLD and ASD, and to understanding the relationship between these disorders.

5.1 Quantitative but Not Qualitative Differences in ASD Symptoms

The hypothesis that adults with NLD would demonstrate social impairments was supported by results for both autism surveys in the first study. The hypothesis that adults with NLD would not endorse non-social autism symptoms, however, was contradicted by the RAADS-R data. Scores supported the description of NLD as a disorder of social perception characterized by social anxiety and pragmatic weaknesses (Johnson & Myklebust, 1967), and added the presence of non-social ASD symptoms such as circumscribed interests, behavioural stereotypies, and sensory sensitivities. Assigning participants to separate groups by the absence or presence of such symptoms, as in research by Semrud-Clikeman and colleagues with children (2010a; 2010b), was not supported in this adult sample. The age of the participants is the most apparent reason for a lack of support for their approach, which was based on differences in the clinical presentation of children diagnosed as having NLD or ASD (Semrud-Clikeman, 2007). It is possible that adults with ASD are more similar in presentation to those with NLD than are children, as a consequence of the impact of maturational, environmental, genetic, and other factors (Karmiloff-Smith, 1998; Nydén et al., 2010). Individuals with ASD appear to learn compensatory strategies for social differences, and both social and non-social autism symptoms seem to lessen (Howlin, 2003; Howlin et al., 2014; Leekam et al., 2011 for a review). However, scores here were not lower on either of the surveys for the ASD group than have been found in other studies, and a lessening of symptoms in ASD adults would not explain the presence of non-social symptoms in the group with NLD.

The latter result raised the possibility that the assumption of an absence of stereotyped behaviours in children with NLD is a consequence of group assignment choices, rather than actual differences between groups. This introduces an uninterpretable circularity: If children show non-social symptoms, they must have ASD, and if they have pragmatic weaknesses, disturbances in social reciprocity, but not non-social symptoms, they should be assigned to an NLD category. One alternative is to separate the clinical groups by perceptual organizational weaknesses that define NLD (Cornoldi et al., 2003; Forrest, 2004; Gross-Tsur et al., 1995; Klin et al., 1995; Mammarella et al., 2009; Mammarella &

Cornoldi, 2014; Rourke, 2000; Semrud-Clikeman et al., 2010a; Stothers & Klein, 2010; cf. Grodzinsky et al., 2010). However, in the second study presented here, score ranges for Block Design also overlapped; that is, some participants with ASD had scores that were similar to those of participants with NLD, even though considered by group, mean differences for Block Design performance were statistically significant. Overlap was also apparent for scores on Gestalt Closure, in which performance for the NLD and ASD groups was not statistically different, and the highest scores in the sample were contributed by participants with NLD. Scores for Object Assembly were not different for the ASD and NLD groups, with a small effect in favour of the ASD group. Generally, these measures are considered to be perceptual organizational in nature; however, even classifying them separately as visual-spatial reasoning and gestalt perception measures would not have also separated groups clearly. This is the first illustration of the negative consequences in research of defining these neurodevelopmental disorders by behavioural outcomes alone. This dilemma could not be resolved here, as will be discussed further, although its presence was considered in all of the interpretations presented.

The RAADS-S scoring system captures two dimensions concurrently. The first is severity of impairment, according to the absence or presence of individual symptoms in each domain, and their total as a pattern across subscales (Ritvo et al., 2008). For example, if an individual endorses the presence of items related to sensory motor, language, and social anxiety symptoms, it is reasonable to infer that he or she is more affected than is another respondent whose symptoms are mostly linguistic. The scale also asks participants to consider the duration of behaviour that indicates ASD – whether the behaviour has been present for the participant's entire life, whether it is no longer present or no longer has an impact as the respondent has matured, or whether the participant believes that a symptom is only affecting his or her life as an adult.

The latter rating complicates the interpretation of negatively worded symptoms. The option was intended to capture improvement due to maturation or treatment (Ritvo et al., 2008). For example, in response to Item 26, *I like having a conversation with several people, for instance around a dinner table, at school or at work,* a participant with NLD (and a RAADS-R score of 124) responded: "True only now, but I'm still not a fan,"

suggesting adaptation to a social convention. For negatively worded symptoms, however, a response of *True only now* is more difficult to interpret. A symptom such as *I like things to be exactly the same day after day and even small changes in my routines upset me,* seems unlikely to spontaneously develop in an adult, at least in the absence of mental illnesses. Instead, endorsing such items as being *True only now* might indicate an increase in awareness of symptoms. In that case, the total score indicating severity would be increased as a consequence of an increasing awareness of self, which in ASD is a lessening of symptoms. On casual inspection, there were instances of *True only now* responses to negatively worded items, but they seemed to appear in participants in all groups. This aspect of the RAADS-R was not explored here, but could have contributed to higher scores than expected if they occurred more frequently in the group of adults with NLD, who were 'not-ASD' and reported some mental health concerns (cf. Sizoo et al., 2015, described in Chapter 2).

That the NLD and ASD groups were not significantly different on two subscales of the RAADS-R is, in particular, a result that should be investigated further in a larger sample. In accordance with case studies (Davis & Broitman, 2011; Mamen, 2007; Myklebust, 1975), the first subscale result suggested the possibility of a potential difference between groups, at least as they are currently defined: that individuals with NLD make more social attempts than those with ASD – as reflected by lower (less impaired) scores for the Social Relatedness subscale – but have as much anxiety about social contact as those with ASD, as reflected by equivalent means for the Social Anxiety scale. Speculatively, if NLD and ASD are not different disorders, the subscale results might have reflected categories described by Wing (1997; Wing & Gould, 1979): *active but odd*, in which behaviour may result in social rejection and a corresponding worry about socializing, versus *passive and aloof*, in which social reciprocity is limited.

The other subscale for which there was greater overlap was Language. There was no statistically significant difference between the NLD and ASD groups. The effect size indicating less impairment in the NLD group was moderate, suggesting clinical relevance, but because the scale was a mixture of pragmatic and figurative items, it was not possible to determine the relative influence of either factor. A thorough exploration

of potential similarities and differences between NLD and ASD groups for language-related autism symptoms would be of benefit, including a pragmatics scale. Other comparison groups should be added, in particular participants with PLI, given the presence of non-social symptoms seen in adults with this diagnosis (Whitehouse et al., 2009). A comparison with participants diagnosed with DSM-5 Social (Pragmatic) Communication Disorder (APA, 2012) would also be of benefit, as the definition of the new classification overlaps with the language characteristics of adults with NLD seen here (Norbury, 2014).

Another research possibility arising from the survey results is that the SRS-A has been revised, with an informant survey as well as a self-report version now available for adults (Frazier et al., 2014). Similar results using a second set of surveys would support the interpretation that the finding for elevated scores reflected actual differences in the participants with NLD, and was not due to a test-specific property of the RAADS-R. In that case, a practical application is suggested, in that self-report tools for adults with either disorder have the advantage of identifying priorities for treatment, according to the views of individual clients (Ritvo et al., 2008). The present results, in which a range of ASD symptoms was endorsed by adults in both diagnostic categories, as well as the larger nosological issues described at the outset, suggest that clinicians should not rely on diagnostic labels alone to specify treatment priorities.

5.2   Breadth and Character of Vocabulary: No Differences

The hypothesis that adults with NLD and ASD would not differ from control participants in breadth of vocabulary, but would nonetheless demonstrate subtle differences in semantic representations as compared with controls, was supported in both groups. Numerous studies have commented on the unusual quality of semantic representations in NLD and ASD (Adams, 2002; Boucher, 2007; Church et al., 2000; Dorfman, 2000; Foss, 1991; Johnson & Myklebust, 1967; Minshew et al., 1995; Perkins et al., 2006; Rourke & Tsatsanis, 2003; Rumsey & Hamburger, 1988; Stein et al., 2004; Thompson, 1997; Volden & Lord, 1991; Wing, 1981; Worth & Reynolds, 2006; Yalof, 2006), but the present study was atypical in that word knowledge in the clinical groups was thoroughly

examined, a test of verbal reasoning was included, and examples documenting a range of differences were provided (cf. Rumsey & Hamburger, 1988; Tsatsanis & Rourke, 1996). That cognitive factors were examined for their potential contributions to differences in semantic representations will be addressed in the next section.

There was no support for the hypothesis that groups would differ in expressive versus receptive vocabulary. It is not necessarily the case that an expressive over receptive advantage would be seen on standardized tests in verbally capable adults. If the number of words used to express an idea does not affect test scores, the garrulous nature of expression noted in NLD and ASD (Adams, Green, Gilchrist, & Fox, 2002; Davis & Broitman, 2011; Foss, 1991; Happé, 1994; Johnson & Myklebust, 1967; Shriberg et al., 2001; Rourke et al., 1990; Rourke & Tsatsanis, 1996; Stein et al., 2004; Yalof, 2006) should not confer either an advantage or a disadvantage. The observation of empty language in the face of verbosity implies that receptive language will be weaker than expressive; that is, the number of words produced might be assumed to be a product of a larger lexicon. This is a reasonable assumption in people without developmental disorders (Corrigan, 2008), but the data here suggested that it is not the case in NLD or ASD, in which pragmatic weaknesses appeared to be unrelated to vocabulary breadth. Some have described this as a difference between simple and complex language (e.g., Minshew et al., 1995). Here it was interpreted as dissociation between breadth and depth, which will be discussed further.

Other studies have suggested that one source of typical vocabulary breadth in NLD and ASD is a strength in rote memory, which has been said to be at least average, if not exceptional, in both disorders (Boucher, 2007; Little, 1993; Myles & Simpson, 2002; Rourke et al., 2002; Wing, 1981). Although memory for facts and details, or semantic memory, was not examined directly in the present sample, generally average to superior results for Vocabulary, EVT-2, and PPVT-4 suggested that memory for word definitions was unimpaired. Academic success, demonstrated by the completion of secondary education by all participants, also supported the existence of good memory for language in the current sample. Two adults with ASD and one with NLD spontaneously reported reading and memorizing word definitions out of interest, outside of school. As well, the

instances of sophisticated vocabulary in both clinical groups were consistent with case reports described in the Introduction (e.g., Asperger, 1944/1991; Mamen, 2007; Palombo, 2006; Stein et al., 2004; Wing, 1981; Yalof, 2006) in which children with social imperception disorders were described as being capable of learning new vocabulary more quickly and easily than some of their peers.

In summary, the quality of vocabulary was an apparent marker of difference in the present sample of adults with NLD and ASD that nonetheless did not distinguish quantitatively between groups. In children, such breadth has been noted to create expectations for equivalent emotional and behavioural maturity that may be developmentally unrealistic (Foss, 1991; Mamen, 2007; Palombo, 2006; Ris & Nortz, 2008; Worth & Reynolds, 2008; Yalof, 2006). It seems reasonable that a disparity between expectations and capabilities documented in children also occurs in adults, at least those who have unusual vocabularies in combination with the social impairments reported in the first study. This possibility was not explored here, but is noted as a direction for future research.

5.3 Gestalt Perception and Semantic Integration: NLD more than ASD

The hypothesis that nonverbal perceptual organization influences the formation of semantic representations, and more specifically, that weaknesses in gestalt perception affect semantic integration by impairing the formation of gestalt concepts, was supported to a greater degree in the NLD than ASD group. This conclusion was based on one measure of semantic integration, however, that in itself may not be enough to rule out the presence of difficulties in the ASD group. As reviewed in the Introduction, there is more evidence of semantic integration difficulty in ASD than has been provided by limited research with NLD participants on this topic. However, the results in Experiment 2 of the second study were not equivocal. The ASD participants as a group performed as well as controls on Remote Associates Problems. This occurred independently of the ASD group having more difficulty than the Control group with Object Assembly, the task that was hypothesized to be a nonverbal equivalent of Remote Associates. In contrast, the NLD group had lower scores for the latter test than either the ASD or Control groups.

Potential explanations for this unexpected result include (a) measurement and operationalization issues, (b) a real divergence between the ASD and NLD groups, at least in the relationship between semantic integration and gestalt perception and (c), better access to formulaic language in ASD than in NLD.

Regarding the first possibility, only the test of Remote Associates was used to measure semantic integration. Although the test was operationalized as a measure of semantic integration, solutions also appeared to rely on access to highly familiar formulaic language, or collocations, as discussed in Chapter 3. Rather than producing a novel concept, correct solutions to the puzzles recapitulated connections between word pairs. Stimuli chosen (Appendix A) were not examined for associative strength between the three pairs that make up each puzzle, nor were the correct answers rated for familiarity. As well, depth of semantic representation was not examined separately in ASD due to time constraints. Last, results for Gestalt Closure, a second nonverbal measure of gestalt perception, were difficult to interpret because of a change in its administration between the second and third studies.

In spite of these limitations, the difference in results for Remote Associate Problems between the NLD and ASD groups is of interest. Examining the unambiguous difference between groups for Block Design suggests two potential reasons for this difference, related to the separation of gestalt perception from general visual-spatial abilities described in the Introduction. To reiterate, Block Design is described as a test of spatial visualization and nonverbal concept formation, including both analysis and synthesis of part-whole relationships (Kaufman & Lichtenberger, 1995; Wechsler, 1997). However, solving the puzzles may rely to different degrees on analysis or synthesis. Dividing each puzzle into its four or nine constituent squares, and then visualizing the relationships between them before placing the cubes, is a purely analytic strategy. In this approach, synthesis is not required until participants check that the solution matches the overall pattern they are copying. The puzzles may also be solved by trial and error, including more frequent comparisons between partial designs and the template, although time constraints will reduce scores for participants using this strategy. Synthesis earlier in the process has been found to be detrimental, as some of the designs look like objects that

can be verbalized (e.g., a flag or a cross), and others do not. Patterns that are recognizable have been characterized as more difficult for individuals without ASD to solve because this recognition competes with the analysis of relationships between individual blocks (Caron et al., 2006; Shah & Frith, 1983). For these reasons, Block Design may measure different abilities in ASD than it does in NLD; that is, the former group may use a more analytic strategy than the latter, and vice versa, so that the test taps most fully into different cognitive processes by group.

From this perspective, it was less surprising that scores for Block Design diverged from scores for verbal gestalt formation in the ASD group and converged in the NLD group, if the best performance on Block Design does result from suppressing gestalt perception and relying on analytic reasoning (Shah & Frith, 1983). In the ASD group, average or better performance for Block Design was seen in combination with better Remote Associate Problem scores. It is possible that the analytic nature of Block Design, rather than its visual-spatial demands, was protective. The stimuli for Remote Associates were not notably reliant on the identification of visual-spatial relationships. Instead, it is possible that solutions to Remote Associates were facilitated by strong local processing in ASD if close associations between the test stimuli and their solution words existed, although, as noted, this feature was not evaluated prior to collecting data. This suggestion has been examined as a weakness in ASD linguistic profiles, in which access to well-learned connections between words has been linked to the early presence of echolalia (Minshew et al., 1995; Strandburg et al., 1993).

In comparison, weaknesses for the groups with NLD in Block Design in both the second and third studies may have had additive effects. Low scores suggested that the group did not have the potentially beneficial influence of ASD-like enhanced perceptual processing (Mottron, Dawson, Bertone, & Wang, 2007) at a local level (Shah & Frith, 1993). As well, in Experiment 1 of the second study, participants with NLD mislabelled shapes, described directions in reverse, and in general demonstrated difficulties with spatial language consistent with lower scores for Block Design (Humphries et al., 1999). Here, the participants with NLD had lower scores for Remote Associate Problems than did the group with ASD, whose nonverbal gestalt perception scores were lower than Control

group scores only for Object Assembly, but not Block Design. In the NLD group, scores for Object Assembly, Block Design, and Gestalt Closure were seen in combination with lower scores for depth of semantic representations, essentially a measure of semantic integration over time, as compared with the Control group.

As noted, the potential relationship between Remote Associate Problems and Gestalt Closure, as measured in the second study, was less clear. Neither the ASD nor Control groups had scores for Gestalt Closure that were commensurate with their other cognitive and language results, likely due to a nonstandardized administration. This is an issue that could be resolved with more than one measure of semantic integration, in combination with standardized tests of nonverbal gestalt perception, compared between groups.

A third possibility based on the assumption of an actual difference between clinical groups concerns processing demands involved in semantic integration. In our review of structural language in NLD and Asperger syndrome (Stothers & Oram Cardy, 2012), we asked whether the influence of structural language on atypical communication in Asperger syndrome differs in comparison to its impact in NLD, or whether language profiles are indistinguishable. Having investigated a small portion of this larger question, the present results supported both outcomes in semantic representation. Groups were similar in their presentation of unconventional but correct terms, and in their imprecise representations for others. They were different in that results for Remote Associate Problems diverged. It is possible that if there is an actual difference between groups, better performance in the ASD group on one of two tests of gestalt perception, in combination with access to formulaic language, permitted compensation for semantic integration difficulties that have been seen in other research (Gold et al., 2010; Hala et al., 2007; Jolliffe & Baron-Cohen, 1999). From this perspective, it might be that the NLD group was less able to compensate in this way because of weaker overall visual spatial and perceptual organizational weaknesses, including gestalt perception ability. These outcomes are not mutually exclusive, but perhaps a more ASD-like pattern would have the potential to mask semantic integration difficulties that were apparent here in individuals with the perceptual organization deficits that define NLD. This proposal is explained in more detail next.

5.4   Collocation Without Representation

Research in ASD (Ambery et al., 2006; Boucher, 2007; 2012; Dichter, Lam, Turner-Brown, Holtzclaw, & Bodfish, 2009; Rumsey & Hamburger, 1988); observations in both groups in the second study (Chapter 3); and clinical experience with adults with NLD (Chapter 4), have suggested problems with verbal fluency, or generativity, in both groups. Results for Homographs supported this type of difficulty in the NLD group. Participants were able to access familiar word associations (a *fair* is a *carnival*) but were less likely than the Control group to generate less common ones (*fair* is a *judgment* between poor and good). If language is a preferred mode of communication in part because of either or both of perceptual or social difficulties, and yet its formulation, depth, and social use are also restricted by the same impairments, a solution to a communicative difficulty is to rely on long-term memory for single words and for scripts or templates – in other words, to rely more heavily than others on formulaic language instead of more typical, generative approaches. In ASD, repetitive use of language has been imputed to impaired imagination, as well as to problems with understanding emotions and the minds of others (Boucher, 2007; Perkins et al., 2006; Turner, 1999). In NLD, disorders of content (Tsatsanis & Rourke, 1996) or cocktail party syndrome have been described (Rourke et al., 2002), but not examined; the potential contribution of formulaic language to this phenomenon also has not been studied.

As seen in the last chapter in participants with NLD (*fair weather* is *cloudy* [sic]), and described in individuals with ASD, the strength of rote memory for single words and collocative phrases may not be related to comprehension (Minshew et al., 1995; Perkins et al., 2006; Volden et al., 2009; Wing, 1981). An adult case study (Boucher, 2007) described JS, an academic with ASD with superior semantic memory. As a child, JS acquired new vocabulary in the manner seen as precocious by teachers and parents. However, as an adult, JS continued to learn words and everyday information by memorization, aware that his method was laborious and unlike the incidental learning that occurs without effort in others (Corrigan, 2008; Rosenthal & Ehri, 2008; Wagovich & Newhoff, 2004). Similarly, during data collection there was a quality of inflexibility and repetitiveness to responses by the participants with a diagnosis. A participant with a

diagnosis of NLD and a RAADS-R score of 81 explained it this way: "I find a pattern in a way to express mostly technical things, or feelings, if I find it works to get someone to understand what I'm saying". Although she reported using these patterns or phrases repeatedly to describe complex situations, she found it difficult to produce a specific example on demand. JS was also reported to have difficulty with generativity, recounting difficulty with writing academic papers, despite being knowledgeable about his topics (Boucher, 2007).

In sum, a reliance on familiar, rehearsed language appears to be a compensatory strategy in both clinical groups that is less effective in situations where verbal fluency is required, or when an incorrect representation has been learned. It is proposed that regardless of whether a semantic representation is correct, it is more likely to have been stored intact, without updating or revision. As discussed next, lack of revision may be related to the tendency just described for using rote memory to acquire new vocabulary, to reduced opportunities to elaborate on word meanings, and to gestalt perception weaknesses as they were linked to semantic depth in the previous chapter. The outcome of this process is what I termed *collocation without representation*, in which the quality of semantic representation relies on memorization to a greater degree than usual.

Typical acquisition of word meanings involves the integration of multiple, embodied sources (Barsalou, 2008; Corrigan, 2008; Coulson, 2006; Meteyard et al., 2012). These include sensory and affordance information, or experiential data, as well as distributional data (Andrews et al., 2009). Distributional data involves the frequency of word appearance in the environment, such as incidental exposures in reading and conversation, thus including social feedback. Both methods support the addition of semantic depth to already known words (Borovsky, Elman, & Kutas, 2012; see Lev-Ari & Keysar, 2014 for individual differences; Vulchanova et al., 2015, for similar evidence in metaphorical language). A reduction in the number of usual sources for vocabulary learning would be compatible with an atypical unfolding of language acquisition in NLD and ASD. Results from the survey study were consistent with reduced social reciprocity for both groups, but to a greater extent for participants with ASD. Results for Estimation data in the depth of semantic representations study supported a contention that individuals with NLD abstract

less information from sensory and affordance experiences as a result of their perceptual impairments (Johnson & Myklebust, 1967; Myklebust, 1975). In both cases, one would expect reduced depth of semantic representations in adults; this was seen for the NLD group, but was not tested directly in ASD. There were instances of difficulties in describing the functions of objects during the Vocabulary test in both clinical groups, as noted in Experiment 1 of Study 2, above.

In contrast to rote memory strengths, episodic memory weaknesses have been described in NLD and ASD. Boucher (2007) noted that in JS, superior semantic memory was accompanied by impaired episodic or relational memory, which requires the integration of modally diverse and contextually situated personal information   JS continued to rely on language to form and maintain memories for events in his life; without verbalizing, memorizing, and rehearsing verbal narratives that he formed to reflect his everyday experiences, he would not remember them (see also Brown et al., 2012; Crane & Goddard, 2008). That is, he compensated for his difficulty with relational memory with a verbal, repetitive, strategy. Although Boucher (2007) reported a strength in perceptual memory in JS, the reference was to memory for simple, single unit, perceptual experiences (p. 261). Here, JS's difficulty with relational memory was interpreted as a more ecologically valid form of gestalt perception deficits that were measured; gestalt perception and the formation of novel concepts require coordinating information of any modality from varied sources (Bell, 1991; Booth et al., 2002; Coulson, 2006; Dien, 2009; Fauconnier & Turner, 1998). Palombo (1993) linked nonverbal gestalt perception deficits with an overreliance on verbal strategies in describing an adult woman with NLD, self-described as a person with secondary autism. In this case, the client was characterized as someone who used language almost exclusively as a way of integrating her life experiences, as a consequence of, and a response, to her visual perceptual deficits. Palombo also connected this reliance on language for memory to an overall interference with the development of a coherent self-narrative, a point that evokes Myklebust's assertion that impairments in perception affect lived experience itself (1975).

Theories of memory also incorporate elements of perceptual organization that are weaknesses in NLD. Mandler (2002) describes the influence of gestalt concepts on an

organisational rather than behavioural account of memory, in which the discovery of structural or organizational relationships between that which is to be remembered and pre-existing knowledge is the critical factor. Mandler equates the perception of structural relationships with finding meaning:

> meaning is in the structure in which the item is embedded… [M]emory does not primarily involve the learning of lists, nor the identification of previously encountered events… [As] we speak and retrieve what we know, we are primarily concerned with conveying meanings – not words or lists or items. (p. 336-337)

This analysis is relevant to the present results for the clinical groups, perhaps in slightly different ways. For the NLD group, lower scores for Block Design and Gestalt Closure were related statistically to poor semantic depth. It was suggested that part of this difficulty was due to lesser ability to construct links amongst and between semantically related representations such as *point*, *score*, and *tally* (see also Stothers & Klein, 2010). Average scores for Gestalt Closure in the ASD participants may have made semantic integration less of a problem, although depth of semantic representation was not examined specifically. Instead, it is proposed that good performance on Remote Associate Problems may have been related to better access to formulaic language, to better analytic or local processes, and to less difficulty with nonverbal gestalt perception. Observations of collocations such as *to exercise caution* for rash; *waif-like* for bashful; *what's good for the goose,* unrelated to the topic; and *unorderly conduct at the scene*, used without a related prompt, appeared to be consequences of having used these phrases in similar, but not identical circumstances. The repetition documented in both groups during data collection seemed to be without purpose. It is the emptiness or lack of content commented upon in many other studies that here is proposed to be a consequence of weaknesses in gestalt perception, strengths in semantic memory but reduced opportunities to add depth, and a reliance on linguistic over nonverbal social communication.

A research consequence of this proposal is that weaknesses in semantic depth that were found for the NLD group would also be expected if the study had included an ASD group, perhaps to a lesser degree according to the list of strengths and weaknesses in the last paragraph. A second is that a follow-up study could examine accurate, inaccurate,

and polysemous semantic representations as they relate to long-term memory for language, in comparison with long-term memory for other sources of semantic representation described in developmental accounts of language acquisition. Some of these would be memory for written text and incidental word learning; memory for descriptions of tool use; comparisons of pictures that do and do not imply activity; and more.

A quotation from a case study of a child with both ASD and NLD features (Stein et al., 2004) highlights relationships between all of these factors:

> "Circuitous" or incoherent speech may result from a style that is marked by verbal associations *[vocabulary]* and fact listing *[formulaic language]* without maintaining a single coherence message *[gestalt perception]* or otherwise adjusting speech to the conversational partner's needs *[social imperception]*. (p. 191)

5.5 Implications

5.5.1 Are NLD and ASD the Same Disorder?

Some results had broader implications for linguistic research and for language interventions. The first was the degree of overlap between adults with NLD and ASD. As noted already, similarities in the survey study for some subscales raised questions about the boundaries between NLD and ASD, and whether differentiation is either possible or useful. On the one hand, the survey results found no qualitative differences. On the other hand, scores for the NLD participants tended to be lower than those with a diagnosis of ASD, a statistically significant difference, on both surveys. The NLD group mean score on the RAADS-R was above all published cut-off scores (Andersen et al., 2011; Ritvo et al., 2008; 2010), and just below threshold on the SRS-A (Constantino et al., 2005; Constantino & Todd, 2004). Given that NLD is not included in any iterations of the DSM or the ICD, there may have been participants in these cross-site, multi-country studies who were more like the current NLD sample than those with ASD. In other regions, individuals with the degree of social imperception that here was associated with a community diagnosis of NLD may have been diagnosed as having Asperger syndrome or a PDD-NOS. Using the RAADS-R, and potentially the SRS-A, in conjunction with tools typically used to identify NLD (Mammarella & Cornoldi, 2014),

therefore might differentiate between these groups, if there is truly a distinction. In combination with a general lack of research on this topic, however, the mixed results in the present study did not permit a definitive conclusion.

Whether distinguishing between NLD and ASD is useful, however, is the more critical question. Survey results indicated that adults with social impairments should not be assigned to research groups according to the presence or absence of non-social ASD symptoms. This caution applies to the consideration of differential diagnosis as well. Thus, potential cognitive and linguistic differences that were explored suggested that investigating these factors has a practical use, at the very least for individuals. Clinically, a diagnosis of ASD does not require ruling out possible learning disabilities. Academic weaknesses might be understood as logical outcomes of ASD, although research on this topic is limited, particularly in adults. Academic outcomes in ASD, however, are as heterogeneous (Brown, Oram Cardy, & Johnson, 2013; May, Rinehart, Wilding, & Cornish, 2015) as are research samples that have ASD (Georgiades, Szatmari, & Boyle, 2013). Results here suggested that knowing whether individuals with either of these social disorders also have visual-spatial, gestalt perception, and semantic integration weaknesses will impact academic and social function, as well as service provision. The research that provided this information, and studies by Semrud-Clikeman and colleagues that directly compare NLD and ASD in children, also provide some support for functional benefits of continuing to explore relationships between these groups. It is suggested, however, that if language profiles were generally understood to be necessary for differential diagnosis, the question would be moot regardless of whether a consensus regarding the nature of the relationship between disorders has been reached.

5.5.2   Measurement of Word Knowledge

A second outcome with broader implications was that information obtained from a thorough investigation of word knowledge and verbal reasoning contributed to understanding the measures of semantic integration and semantic depth. This finding substantiated other reports that standardized measures of vocabulary are not sensitive enough to capture variations in vocabulary that nonetheless impact social communication. The development of better tools is necessary, and has been noted in

other studies and reviews (Corrigan, 2008; Gerber, 2003; Howlin, 2014; Minshew et al., 1995). The lack is particularly relevant in this type of research, in which participants are included because of social imperception. Test batteries such as the Test of Language Competence do compare complex language functions (Wiig & Secord, 1989, cited in Minshew et al., 1995), including subtests for the comprehension of Ambiguous Sentences and Metaphoric Expressions. In the present context, these subtests would be regarded as a measure of gestalt concept formation, relying on the integration of unlike linguistic parts. However, the test battery does not have adult norms, and so was not chosen for this study. In other research on semantic integration, vocabulary has been reported for one expressive measure, usually a WAIS or WASI Vocabulary subtest, and potential differences in receptive, expressive, and verbal reasoning have not been examined. Although none were found here, the possibility of differences in larger or more diverse samples cannot be discounted.

Average vocabulary and verbal reasoning in all participants also highlighted the divergence of breadth from depth in the NLD group, as suggested in our review (Stothers & Oram Cardy, 2012). To be skilled in verbal aspects of social communication requires access to an adequate vocabulary, defined as the quantity of lexical entries as well as their quality (Corrigan, 2008). Semantic depth is evident in knowledge of polysemous definitions, emotional connotations, and links to related terms, and its lack identified by difficulties with verbal retrieval, and verbal fluency. As a group, participants with NLD demonstrated typical quantity, but atypicality in these features of depth. Corrigan (2008) also notes that word knowledge may be partial, regardless of whether a developmental language disorder is present. The statistical discrepancy between breadth and depth that was seen here in the NLD group should be evaluated with a standardized measure normed on a range of ages and language development histories, to determine whether it is in fact a marker of difference in this group. The same possibility should be evaluated with an ASD group, given observational differences recorded in Experiment 1 of the second study; statistical differences for semantic integration in other research (Gold et al., 2010; Hala et al., 2007; Jolliffe & Baron-Cohen, 1999; Lopez & Leekam, 2003; Snowling & Frith, 1986); and the fact that depth was not tested in addition to semantic integration in this group (cf. Landa, 2000).

In general, it is concluded that underlying language abilities of participants should be more thoroughly examined to replicate findings, and make the results more useful to practitioners (Andrews, 2011; Gerber, 2003; Howlin et al., 2014; Kelley et al., 2006; Minshew et al., 1995; Norbury, 2014; Semrud-Clikeman et al., 2010b). Pragmatic weaknesses may be attributable in part to depth of semantic representations and semantic integration abilities, which may be overlooked in the face of average vocabulary breadth. The strong, positive relationship between nonverbal measures and definitions for polysemous words, in particular, implies that matching groups on nonverbal IQ may mask potential differences in semantics. This is another rationale for experimental and clinical assessment of skills that may not appear to be a part of the presenting difficulty.

At the individual level, lack of depth and richness in semantic representations may result in fewer options when interpreting and responding to metaphors, slang, or novel concepts, all of which have been reported to be difficulties in NLD and ASD (Dennis, Lazenby, & Lockyer, 2001; Gold et al., 2010; Martin & McDonald, 2004; Ring et al., 2007; Tager-Flusberg, 2006; Tsatsanis & Rourke, 2003; Vulchanova et al., 2015; see Melogno, Pinto, & Levi, 2012, for a review with children who have ASD; cf. Giora, Gazal, Goldstein, Fein, & Stringaris, 2012; Hacking, 2009). Improving depth would provide more opportunities for avoiding concrete or literal interpretations, also common to NLD and ASD pragmatic errors (Jolliffe & Baron-Cohen, 1999; Saalasti et al., 2008; Semrud-Clikeman, 2007; Tsatsanis & Rourke, 2003). The opportunities that depth and flexibility of semantic representations provide also rely on prompt and reliable access, as problems with word-finding are a barrier to communication (Dockrell, Messer, & George, 2001). In the present study, access difficulties were flagged by repetitions, fillers, self-corrections, and lengthy responses, which appeared more frequently for the clinical participants (Chapter 3). Other research has found a tendency in both clinical groups to recall lists serially rather than in meaningful clusters (cf. Mandler, 2002), as well as more general difficulties with verbal fluency (Boucher, 2007; 1012; Bowler et al., 2009; 2010; Fisher & DeLuca, 1997; Jolliffe & Baron-Cohen, 1999; Spek et al., 2009; Verté, Geurts, Roeyers, Oosterlaan, & Sergeant, 2006; Stothers & Oram Cardy, 2012, for a review). From this perspective, studying the contribution of less well-developed semantic representations to disordered pragmatics may lead to alternatives for treatment.

Concentrating on the quality of semantic representations and potential difficulties with semantic integration may be as advantageous to adults with NLD and ASD for some types of pragmatic difficulties as social skills interventions appear to be.

Overall, both quantitative data and observational details were added to clinical descriptions of vocabulary errors that are typical of adults with NLD and ASD. Consideration of cognitive processes that are not necessarily either verbal or nonverbal added to the understanding of the nature of semantic integration. In the case of NLD, the data supported a hypothesis about the developmental course of disordered content (Tsatsanis & Rourke, 1996; Paul et al., 2009). The data were also consistent with previous explanations of general cognitive differences in both of these groups, such as a more narrow, gestalt but not global, version of WCC (Brosnan et al., 2004; Kimchi, 1992) in ASD (Fisher, Happé, & Dunn, 2005; Paynter & Peterson, 2010; Saalasti et al., 2008), and visual-spatial and gestalt perception deficits in NLD (Stothers & Klein, 2010; Worling et al., 1999).

5.6   Relevance

To return to the motivation for these studies, it was noted in the Introduction that language is understudied in NLD and ASD. As discussed in Stothers and Oram Cardy (2012), social difficulties apparent in these disorders have directed attention away from the investigation of language (Groen, Zwiers, Gaag, & Buitelaar, 2008; Humphries et al., 2004; Volden, 2004). However, benefits of considering the quality and formation of semantic representations as distinct from pragmatics were seen here. The present studies explored the nature of word knowledge and semantic integration outside of the context in which they were expressed, as much as was possible. Some participants with social impairments may perform well when they are tested in structured settings, with clear instructions about what is expected of them, and starting and stopping points that are defined in advance (Gerber, 2003; Klin et al., 2007; Volden et al., 2009). At the same time, social anxiety might lower performance in either group. It was not possible here to determine to what degree social interaction during data collection affected performance,

but that the majority of the data was collected by one person lessened the influence of this potential confound.

The clinical relevance of this type of investigation is apparent. Developing spoken language strongly predicts better outcomes for individuals with ASD (Howlin et al., 2014; Mawhood, Howlin, & Rutter, 2000; Szatmari, Bryson, Boyle, Streiner, & Duku, 2003; Tager-Flusberg et al., 2009; Tidmarsh & Volkmar, 2003). Improvements in language in adults with learning disabilities better allow them to compensate for the cognitive weaknesses that define their disorders (Mather & Gregg, 2006). Referrals for interventions that focus on language and communication abilities in these populations are increasing (Bastiaansen et al., 2011; Mitchell, 2015; Volden, 2004; Young, Diehl, Morris, Hyman, & Bennetto, 2005), and more information about underlying impairments and characteristic outcomes in NLD and ASD will assist clinicians in designing effective interventions.

Examining the specific contribution of semantic representations to pragmatics also lessens the circularity of discussing social imperception solely as a problem of disordered social communication in NLD and ASD, avoiding to some degree the difficulty of clearly dividing these areas of language from each other (Norbury, 2014; Scheeringa, 2001). Pragmatic differences do not account for academic difficulties such as writing multiple choice format examinations (Stothers & Oram Cardy, 2016) or having difficulty with reading comprehension (Stothers & Klein, 2010). It is more apparent in academic work that the possibility of an underlying difference in a given representation may affect comprehension. In discourse, errors may be unknown until they are expressed to a conversation partner. This approach appears to be rare in the studies that were reviewed (cf. Gold et al., 2010).

5.7 Novelty

There were other design decisions that distinguished the present studies from others. The studies here involved adults who had apparent strengths in the areas of investigation. Other than research conducted by Mottron and colleagues (2006; 2007) in exploring

lower level perceptual functions in ASD, little attention is paid to strengths in ASD (see Happé, 1999 for discussion) or NLD. As well, the choice to include a descriptive approach in data collection (see also Kamp-Becker et al., 2010) and in discussing the results acknowledged unclear boundaries between NLD and ASD provided clinically useful information about these adults and their language. Survey research, in particular, has rarely commented on participants without disabilities who nonetheless score outside of normal ranges. These scores may be treated as statistical noise but they may reflect a group of people with identifiable psychosocial or cognitive difficulties. Additionally, dividing learning disabilities by type, even very broadly as was the case here, is not usually done, restricting conclusions that can be drawn (e.g., Buchanan, Storey, & Atchley, 2004; Dool, Stelmack, & Rourke, 1993; Stelmack, Rourke, & van der Vlugt, 1995; Stothers & Klein, 2010). When NLD is considered separately from other learning disabilities, much of the literature applies Rourke's model of NLD to a comparison of high-functioning autism with Asperger syndrome at a theoretical level, rather than directly comparing individuals on the spectrum to those with NLD (cf. Semrud-Clikeman and colleagues). Finally, here the consideration of the contribution of underlying cognitive processes to semantic integration was not restricted by modality. Predictor variables in the previous semantic integration studies reviewed in the Introduction were restricted to verbal abilities, reserving nonverbal measures as a method of equating intelligence in their samples. The relationship between nonverbal IQ and semantic representations has been explored infrequently (Stothers & Klein, 2010).

As a consequence of these choices, results that were compatible with previous research, but had not been previously demonstrated, emerged. These included: (a) quantification of social imperception in adults with NLD, (b) quantitatively more social imperception for participants with NLD than those without a clinical diagnosis on ASD surveys, (c) significantly lower social imperception scores for NLD than ASD participants, but no substantive differences in the pattern of differences across the two clinical samples, (d) quantification of the divergence between vocabulary breadth and depth in NLD, (e) gestalt perception weaknesses in both clinical groups, independent of fine motor and visual-spatial abilities, (f) correlations between measures of nonverbal gestalt perception and both depth of semantic representations and an experimental measure of semantic

integration, and (g) two potential markers of NLD: Homographs and Estimation. Other findings elaborated and supported conclusions already reported in the literature, including overlap between NLD and ASD in social imperception (Semrud-Clikeman et al., 2010b), normal breadth of vocabulary in both clinical groups (Stothers & Oram Cardy, 2012), and qualitative differences in vocabulary use, known as cocktail party syndrome in NLD (Rourke et al., 2002), and verbosity and professor-like speech in ASD (Wing, 1981).

5.8 Future Research

A number of potential studies were noted throughout. Ideas that are most pertinent to language included (a) revisiting social impairment measures in a larger sample with additional comparison groups, (b) investigating the possibility that social anxiety is more ASD-like than is social responsiveness in adults with NLD, (c) extending the exploration of Homographs and Estimation to an ASD sample, (d) a full examination of prosody in NLD, (e) longitudinal studies of depth of semantic representations in clinical groups and in typically developing children, adolescents, and adults, and (f) a study of the N400, an event-related potential that is generally characterized as reflecting semantic integration (Kutas & Federmeier, 2011, for a review of the interpretation of the N400).

In regard to options (c) and (d), the results for collocations were promising, but were based on a smaller subset of the total sample of 50. A similar limitation is clearly true of the exploratory word stress item. A full investigation of word stress and other aspects of prosody would be of benefit in NLD, especially in comparison with research in this area with ASD participants (e.g., Eigsti et al., 2012). Vocabulary and Homograph comparisons should also be made with groups of participants who have ASD and other learning or developmental disorders, such as dyslexia and specific language impairment, to further examine the relationships between word knowledge, its depth, and perceptual organization.

In ASD there is a growing interest in adults with so-called *optimal outcomes*, or those who would no longer qualify for a diagnosis of ASD based on gold standard measures of autism symptoms (Kelley et al., 2006; Suh et al., 2014). In learning disabilities, adults with phonological impairments whose reading comprehension and general literacy are

within normal limits have been called *compensated dyslexics* (Birch & Chase, 2009; Chiarello, Lombardino, Kacinik, Otto, & Leonard, 2006). There is no corresponding classification for adults with NLD who have been diagnosed as children but have not used ongoing academic or employment accommodation. Three of the participants in the NLD group appeared to be similar in this respect to individuals described as having optimal outcomes or compensated reading disabilities; they had scores for both ASD surveys below threshold, and had average to above average scores for Block Design, Object Assembly, or Gestalt Closure. These participants were male, and had Vocabulary scores in the above average or superior range. Nonetheless, each of them had responses that were included in the list of unusual responses to Vocabulary, both accurate and inaccurate. The existence of optimal outcomes in NLD, with the subtle but residual differences in language seen in optimal outcome children with ASD (Kelley et al., 2006), is another area for further research.

Another designation that might fit these individuals is giftedness. In reading disabilities, high level strengths are proposed to allow compensation for low level phonological deficits (Chiarello et al., 2006), particularly when reading is untimed (Stothers & Klein, 2010). Some of the participants in the clinical groups here might be classified as gifted by virtue of their IQ scores and academic achievement (Assouline, Nicpon, & Doobay, 2009). It is unknown whether adults with NLD who are also gifted have equivalent, better, or worse social outcomes than typical adults, or than peers with social imperception who are not as intellectually capable. This potential relationship is an area of research that may have implications for mental health, as research in ASD has made a link between higher scores for tests of cognitive ability and depression (Assouline et al., 2009; Sterling, Dawson, Estes, & Greenson, 2008).

5.9 Limitations

Limitations of this study not already discussed were related to generalization. The current sample was unlikely to be representative of the larger population of adults with NLD: There were few participants who were not recent graduates or not currently enrolled in post-secondary education, and only the participants without diplomas or degrees had scores for Block Design or Gestalt Closure in the below average or

borderline range. Adults who have more severe perceptual organizational impairments may not be well-represented in university educated samples, as in the present study. As well, some participants with NLD may have been diagnosed based on intra-individual discrepancy scores; that is, they demonstrated a disparity between higher verbal and lower perceptual reasoning scores on IQ testing, but none of their perceptual reasoning subtest scores was more than two standard deviations below the mean for peers of the same age. This criterion for diagnosis is not universally accepted (Mather & Gregg, 2006; Sparks & Lovett, 2013; Weis, Sykes, & Undakat, 2012). Practically, however, some of the registered psychologists who made diagnoses for participants with NLD in the present study do consider intra-personal discrepancies in their decision-making. In spite of this limitation, information about adults with good intellectual capabilities is of use, given that more adults with learning disabilities are enrolling in post-secondary school than ever before (Griffin & Pollak, 2009; Harrison & Holmes, 2012; Holmes & Silvestri, 2012; Parsons, Lewis, & Ellins, 2009; Sparks & Lovett, 2013).

Advanced academic achievement and independent living were characteristic of the ASD group as well. The majority of participants had either completed a degree or diploma or were working toward one, and only three of the 21 participants with ASD reported relying on others for assistance with everyday activities. It was also the case that the Control participants were not representative of a general adult population, as they tended to be very well-educated and have better than average vocabulary scores. In that sense, they were an appropriate reference group for the clinical participants, but could not be assumed to be typical of the general population with high school diplomas.

5.10 Conclusion

Research in NLD and ASD most often concerns children. Increases in public and professional awareness of these disorders, as well as advances in human rights legislation, have resulted in more adults with NLD and ASD becoming involved in aspects of community life that may have been unavailable to them in the past. Many participants in the present sample were employed or engaged in job training. Almost all participants had at least some post-secondary education, some had professional or graduate degrees, and some were living independently with spouses and children. In

general, participants in both clinical groups reported fewer adaptive difficulties than were seen in larger samples of adults with ASD described by Howlin and colleagues (Howlin et al., 2014; Magiati, Tay, & Howlin, 2013; see also Anderson, Shattuck, Cooper, Roux, & Wagner, 2013; Roux et al., 2014). At the same time, participants reported struggling with the consequences of their differences, and some asked about resources that would help them cope. Given both of these circumstances, more adult research is necessary to answer questions about the influences of post-secondary education, employment, and long-term relationships on outcomes, as well as the development of compensatory strategies over time.

It is also the case that better understanding the end point of developmental trajectories may shed light on paths that diverge from typical development. More research is necessary with adolescents, young adults, and older adults with a lifetime of experiences and adaptive strategies to share. Longitudinal studies of relative or outright strengths such as vocabulary knowledge and verbal reasoning are also critical to better understand unfolding interactions between the factors that were examined here. Finding valid and reliable cognitive and linguistic markers of NLD and ASD would assist service providers in a wide range of helping professions in making appropriate referrals and assisting adults with advocacy.

The present work highlights strengths in NLD and ASD, in part because of generally negative accounts of these disorders in the academic literature. To focus on assets and achievements exclusively, however, is to risk minimizing the struggle that adults in the study and former students have described. There is a balance between an imperative to present oneself as capable and competent, and a practical need for others to know that at times, accommodation will be necessary.

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Appendix A

Remote Associate Problems

Item	Solution
rocking / wheel/ high	chair
loser / throat / spot	sore
cane / daddy / plum	sugar
cracker / fly / fighter	fire
date / alley / fold	blind
water / mine / shaker	salt
food / forward / break	fast
print / berry / bird	blue
sense / courtesy / place	common
high / district / house	school or court
keg / puff / room	powder
french / car / shoe	horn
carpet / alert / ink	red
peach / arm / tar	pit
piece / mind / dating	mind
pie / luck / belly	pot
age / mile / sand	stone
cross / rain / tie	bow
light / birthday / stick	candle
dress / dial / flower	sun
tail / water / flood	gate
pine / crab / sauce	apple
fork / dark / man	pitch
illness / bus / computer	terminal

Note. All items from Bowden & Jung-Beeman (2003)

Appendix B

Estimation Items and Responses by Group

1. How many slices of bread are there in an average-sized loaf of bread? [a, b]
2. On average, how many children are there in an Ontario public school classroom? [a]
3. How fast do race horses run? [a, b]
4. How long does it take to cook a fish? [b]
5. How heavy is the heaviest dog on earth? [b]
6. What is the length of an average adult male's spine? [a, b]
7. How long does it take an astronaut to fly to the moon? [a]
8. How long does it take to drive from Vancouver to Halifax? [b]
9. How long do you think it took Columbus to sail across the Atlantic Ocean? [b]
10. What is the circumference of the trunk of the largest tree in the world? [b]
11. Approximately how much is this University's annual budget? [c]
12. How much does a compact car weigh? [c]
13. About how long does it take an Olympic athlete to run a marathon? [c]
14. What is the length of the average metered parking space in the downtown core? [c]
15. How long would it take to swim across Lake Ontario from Toronto to New York state? [c]

[a] Shallice and Evans, 1978; [b] Kopera-Frye et al., 1996, [c] Stothers, 2005

Item	Measurement	Actual	Ranges a: 25% b: 50%	Control † Range	NLD Range
1. loaf of bread	width x length	20	a: 15 - 25	12 - 36	12 – 50
2. children	number	25	a: 19 - 31	20 - 35	22 - ten million
3. race horse	speed	64 kph	a: 48 - 70	10 - 90 kph	15 - 500 kph
4. cook a fish	duration	10 - 15 minutes	a: 5 - 22 minutes	7 - 60 min	5 - 90 minutes
5. heaviest dog	weight	280 lbs	b: 140-280	20 - 500 lbs	40 - 300 lbs
6. adult spine	length	2.25 ft	a: 1.75 - 3 ft	.5 - 4 ft	.31 - 16.4 ft
7. space flight	distance x speed	84 hrs	60 - 108 hrs	6 - 504 hrs	28 ms - 1440 hrs
8. x-country	distance x speed	57 hrs	43 - 70 hrs	40 - 604 hrs	4 - 1440 hrs

9. x-ocean	distance x speed	5 weeks	3 - 7 wks	2 - 250 weeks	3 - 365 days
10 tree trunk	circumference	33 m	25 - 40	2.7 - 50 m	.2 - 200 m
11. budget	amount	$750,000	$350,000 - 1 billion	1.5 million - 1 billion	$1,200 - 1 billion
12. compact car	weight	3000 lbs 1.5 tons	2250-3750 .75 - 2.25	600 lbs - 10 tons	30 lbs - 10 tons
13. marathon	distance x speed	2.25 hrs	2 - 3 hrs	1 - 6 hours	1 min - 7 hrs
14. parking spot	length	5 m	4 - 6.5 m	2.13 - 4.88 m	1 ft - 6.7 m
15. lake swim	distance x speed	36 hrs	27 - 45 hrs	1 - 96 hrs	2 - 2,016 hrs
Unit Errors	e.g., ms for hrs; days for wks	–	–	0 - 2	0 – 5

Note. ms = milliseconds. Actual amounts were researched online via reputable websites (e.g., City of London; International Olympic Committee, etc.). Ranges are either 25% or 50% plus or minus the actual amount, depending on the similarity of the resulting range with the ranges that were used in the source materials.

† All outlying estimates in the Control group were provided by the same three participants; none reported a history of developmental disorder.

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Appendix C

Homographs

fair:
- carnival
- just or equitable
- pleasant weather
- light colouring or skin tone
- a judgment or rating (e.g., poor, fair, good)
- general physical beauty

bank:
- financial institution
- slope, e.g., river, snow
- to travel forward and turn at an angle (e.g., basketball, puck, flight of a plane)
- to rely on or count on
- any pile or collection (e.g., bank of lights)
- storage in general (e.g., blood, food)

diamond
- stone or mineral
- shape (parallelogram, square turned on end)
- one of the suits in a deck of cards
- a playing field
- treasure, gem, or prize of any kind

object
- non-specific tangible, material thing
- focus or purpose of an action or emotion, goal
- a part of speech
- to disagree with*

point:
- to extend one's arm to indicate
- main idea or purpose
- dot (that which has position but no magnitude)
- sharp end
- score or unit of measurement (e.g., a point in a game of Scrabble)
- a place or spot (e.g., the point at which the lines meet)
- land jutting out into water
- a moment in time
- a detail, usually one in a list
        - also other uses of point (e.g., re: bricklaying, dance, sports)

* word-stress item, note 1 meaning each for *ob*ject and ob*ject* = 2/2

Curriculum Vitae

Post-secondary	The University of Western University, London, Ontario
Education:	2008 – present, Ph.D. Candidate
	2005, M. Ed.
	1997, H.B.A.
	1993, Diploma in Art Therapy
	Ontario College of Art
	1986, A.O.C.A.
Honours and	Province of Ontario Graduate Scholarships
Awards:	2010/11 (declined), 2011/12, 2012/13
`	Faculty of Graduate Studies Research Travel Awards
	2009, 2011, 2013
	Health and Rehabilitation Sciences Research Travel Awards
	2009, 2011, 2013
	Queen Elizabeth II Graduate Scholarship in Science and Technology
	2012/13 (declined)
	Research Award, Western University's Autism Centre of Excellence, 2011/12
	Ph.D. Fellowship, Autism Research Training program, CIHR / Sinneave Institute, 2010/11
	Alice E. Wilson Award, Canadian Fellowship of University Women, 2010/11
	Western Graduate Thesis Research Award, 2009
	Ontario Graduate Scholarship in Science and Technology, 2009/10
	Faculty of Health Science Dean's Entrance Scholarship, 2008

Canadian Association of Educational Psychology M.Ed. Thesis Award, 2006

Dean's Honor List, Western University, 1997

Related Work Experience:

Research Assistant, Western
2008 – 2012

Teaching Assistant, Western
2008 – 2010

Learning Strategist, Western
2002 – 2008

Teaching Assistant, King's University College
1997 – 1999

Disabilities Counsellor, Western and King's University College
1997 – 2002

Publications:

Stothers, M. E., & Oram Cardy, J. (2016). Nonverbal learning disabilities and Asperger syndrome in young adults: Vocabulary, gestalts, and social perception. In B. Rissman (Ed.), *Medical and Educational Perspectives on Nonverbal Learning Disability in Young Children and Adults,* (pp. 264-315). Hershey, PA: IGI Global.

Stothers, M. E., & Oram Cardy, J. (2012). Oral language impairments in developmental language disorders with language strengths: A comparison of Asperger syndrome and nonverbal learning disabilities. *Research in Autism Spectrum Disorders, 6*, 519-534.

Stothers, M., & Klein, P. D. (2010). Perceptual organization, phonological awareness, and reading comprehension in adults with and without learning disabilities, *Annals of Dyslexia, 60,* 209-237.

Selected Peer Reviewed Conference Presentations:

Stothers, M. E., & Oram Cardy, J. (2015, May). *Quantifying the behavioural relationship between ASD and NLD: More than social imperception.* Poster presented at International Meeting for Autism Research annual conference, Salt Lake City, Utah.

Kwok, E., Archibald, L. M. D., Brown, H. M., Joanisse, M., Smyth, R., Stothers, M. E., & Oram Cardy, J. (2013, June). *Auditory temporal integration in children with specific language impairment (SLI) compared to same age controls.* Poster presented at Canada-Israel Symposium on Brain Plasticity, Learning, and Education, Western University, London, ON.

Stothers, M. E., & Oram Cardy, J. (2012, May). *Semantic integration in adults with Asperger syndrome and nonverbal LD.* Poster presented at International Meeting for Autism Research annual conference, Toronto, ON.

Oram Cardy, J., Nicolson, R., Archibald, L. M. D., Boehm, J., Brown, H. M., Stothers, M. E., McCarthy, C., & Kwok, E. (2012, May). *Auditory integration as a neural marker of language disorders in autism spectrum disorder.* Poster presented at International Meeting for Autism Research annual conference, Toronto, ON.

Stothers, M. E., & Oram Cardy, J. (2011, May). *Semantic integration in Asperger syndrome: A comparison to nonverbal learning disability*. Poster presented at International Meeting For Autism Research annual conference, San Diego, CA.

Oram Cardy, J., Brown, H., Harder, K., Gilders, L., Shelton, A., Spratt, J., and Stothers, M. (2011, June). *Neural markers of auditory integration in children with Specific Language Impairment*. Poster presented at the Symposium for Research in Child Language Disorders, Madison, WI.

Stothers, M. & Brown, H. M. (2010, June). *Adults with invisible disabilities: Accommodating learning disorders and cognitive differences.* Paper presented at Aiming for Accessibility: Meeting Standards, Making Change, a conference held at the University of Guelph, Guelph, Ontario.

Stothers, M., & Oram Cardy, J. E. (2010, May). *Cognition and social behaviour in adults with Asperger syndrome: A comparison with nonverbal LD*. Paper presented at the International Meeting For Autism Research annual conference, Philadelphia, PA.

Stothers, M. (October, 2009). *A cognitive processing approach to defining learning disability subtypes*. Paper presented at the Council for Learning Disabilities 31st Annual International Conference, Dallas, Texas.

Stothers, M. (May, 2006). *Bridging the verbal / nonverbal divide: Implications for reading comprehension in adults.* Paper presented at the Conference of the Canadian Society for the Study of Education, York University, Toronto, Ontario.

Stothers, M. (June, 2005). *Asymmetries in LD-related cognitive functions and their implications for reading*. Paper presented at the Conference of the Canadian Association of College and University Student Services, Queen's University, Kingston, Ontario.