Available online at www.sciencedirect.com
SCIENCE DIRECT®
Brain and Language 88 (2004) 163–166
Brain and Language
www.elsevier.com/locate/b&l

Introduction

# Issues in plasticity and development: Language in atypical children

Judy S. Reilly[a] and Beverly B. Wulfeck[b,*]

[a] San Diego State University, Laboratoire de Psychologie Langage et Cognition (LaCo), Universite de Poitiers, UMR CNRS 6096
[b] School of Speech, Language, and Hearing Sciences, San Diego State University, Center for Research in Language, University of California, San Diego, CA 92182-1518, USA

Accepted 2 April 2003

## 1. Introduction

The San Diego Project in Cognitive and Neural Development (known as PCND or "the Center") was established 15 years ago by a team of researchers at the University of California, San Diego, San Diego State University and the Salk Institute for Biological Studies. During this time, the focus of the PCND has been to study brain and behavioral development in typically developing infants, toddlers, and children and in children with neurodevelopmental impairments. These studies have been supported by two multi-project center grants (NINDS "Neural Bases for Language and Learning" and NIDCD "Origins of Communicative Disorders"). Although our research encompasses a number of neurodevelopmental domains, e.g., language, attention, affect, and spatial cognition using state-of-the-art behavioral, imaging, and electrophysiological paradigms, this special issue focuses on the products from language studies that have been conducted under the auspices of the PCND.

As the title of this special issue implies, we are interested in investigating evidence for the presence or absence of plasticity in language development among atypical children. The overarching goal of our language studies is to understand the nature, causes, and neural mechanisms of communication disorders. To this end, we conduct prospective studies (both longitudinal and cross-sectional) that identify children at risk for language disorders as early as possible (in some of our populations this may be as early as the first year of life) and follow them through the major milestones of language development, across childhood and into adolescence.

Our studies center on several basic themes for comparative research including: (1) the search for profiles of *association and dissociation* across behavioral domains, (2) cross-sectional and longitudinal studies of *change over time*, (3) "on-line" methods that focus on the *temporal microstructure* of language, (4) studies linking these behavioral profiles and developmental trajectories to specific *indices of brain structure*, and (5) an exploration of the nature and limits of *neural specialization* for language and the complementary issue of *neural and behavioral plasticity*, i.e., alternative forms of organization in the mental and neural processes responsible for language.

To address these themes, we have selected specific populations of children who present contrasting neurobehavioral profiles permitting us to address these issues and to test specific hypotheses that are central to questions of neuroplasticity and the structures and mechanisms of the language system.

## 2. Populations

In typically developing (TD) children, language, and other cognitive systems develop in a more or less integrated manner, and it is thus difficult to tease apart individual components and processes. Each of our special populations provide a unique lens on development and the relations between language and brain; together they permit us to better define the boundaries and subcomponents of systems as well as those aspects which are dissociable and those which are not.

The first group of children from our special populations includes late talkers (LT), and then as they get older, and for those who continue to demonstrate language problems, children with specific language impairment (SLI). Late talkers are toddlers, (20–27 months of age), whose expressive vocabulary falls at or below

* Corresponding author. Fax: +619-594-7109.
*E-mail address:* wulfeck@crl.ucsd.edu (B.B. Wulfeck)


doi:10.1016/S0093-934X(03)00095-6

the 15th percentile on the MacArthur Communicative Development Inventory. Aside from their language delay, performance on the Motor portion of the Bayley Infant Scales of Development are within the normal range. Children with specific language impairment (SLI) in our studies are diagnosed at four to five years of age. These are children whose Performance IQ is within the normal range (above 80), but whose scores on standardized language measures of expressive language fall at least one and one-half standard deviations below the mean for their age. Both these groups of children, LT and SLI, have been screened for neurologic and hearing problems. They show no evidence of frank neurologic abnormalities nor of developmental disorders, e.g., mental retardation or autism. The school aged group of children with SLI present clear and often severe impairments of expressive language, showing profiles similar to Broca's aphasics. Yet unlike the children with early focal brain injury (below), children in the SLI group have no frank neurological impairment, and their performance in other cognitive domains (as measured by non-verbal intelligence) is in the normal range. As a group, these children present a real puzzle: although no systematic patterns of neurologic anomalies have been found, these children have notable language problems.

The second group of children are those who suffered early unilateral focal brain damage. Most of these children (FL) sustained their lesions, pre-or perinatally and all occurred before 6 months of age; lesions were confirmed by either CT scan or MRI. Exclusionary criteria for this group included multiple or bilateral lesions, or a medical history of conditions that might have caused more global damage, e.g., bacterial meningitis. These prospective studies have followed these children from the onset of language. As their lesions were incurred pre-linguistically, they afford an opportunity to map the nature and time course of language development in children with unilateral brain damage. For many of these children the damaged area includes areas that in adults, serve basic language functions, therefore, they represent a unique opportunity to examine brain plasticity for language and the degree to which a developing brain can respond to these early insults.

Williams Syndrome (WMS) is a rare form of mental retardation in which language abilities are relatively spared, and Down Syndrome (DNS) is a form of mental retardation in which language is especially vulnerable. In spite of their intellectual impairment and severe spatial deficits, the relative linguistic strengths of WMS, especially in adolescence, presents a chance to explore dissociations within and between cognitive domains. The course of language development in children with Williams or Down Syndrome is initially delayed, but even from the early stages, the language use in WMS children has a heightened social flavor. Our studies here are designed to better understand how a genetic abnormality can influence language development, with respect to both structure and use.

Taken together, the language behavior of these groups of children permit us to look at associations and dissociations within language; to examine language acquisition per se, and in so doing to identify both limits and areas of resilience with respect to language function; and finally to explore the nature and extent of neural and behavioral plasticity for language. The individual studies in this issue target specific areas of language, e.g., the lexicon, morphosyntax, discourse and verbal memory. They also reflect aspects of linguistic behavior: production, sensitivity to grammaticality and different methodologies: spontaneous discourse, on-line reaction time studies, and behavioral probes to elicit certain linguistic structures. A brief summary of these studies illustrates the breadth and depth of our enterprise.

## 3. Synopses of studies

Thal, Reilly, Seibert, Jeffries, and Fenson, examined first words and early grammar in spontaneous speech for LT, FL, and TD children. Results reveal comparable delay in language production for the FL and LT groups although there is more variability in FL group. However, children with focal brain injury, demonstrate remarkable "development" of language despite early delays. In contrast, while most late talkers outgrow their language problems, some remain delayed throughout school age. To shed light on these somewhat surprising outcome profiles, analyses are conducted to examine how words and grammatical structures used by younger children may predict the growth of language skills under such different neurological conditions.

Mechanisms of verbal memory and learning are the focus of the study by Nichols, Jones, Wulfeck, and Bellugi, who use the California Verbal Learning Test (CVLT) to compare the performance of SLI, FL, WMS, DNS, and TD groups. The study examines how verbal memory relates to phonological, lexico-semantic and other cognitive deficits, as well as lesion location in the FL group. Results suggest the experimental populations encode, organize, and retrieve information in very different ways, despite the fact that they all experience some degree of difficulty with verbal learning and memory.

Weckerly, Wulfeck, and Reilly asked school-aged TD, SLI, and FL children to listen to sentences and complete them with a tag question (*John likes chocolate, doesn't he?*). Production of the appropriate tag question is a complicated operation, in which the child must analyze and manipulate subtle morphological and syntactic information. In general, all groups had problems with the same aspects of grammar. However, while FL

children did as well on every measure as TD children, SLI children did not. It appears that although both groups use similar language learning mechanisms, for SLI children, language acquisition of basic structures continues well into adolescence, while FL children show more plasticity in the potential for language acquisition early on.

In the study by Marchman, Saccuman, and Wulfeck, FL, SLI, and TD children were asked to complete sentences with the past tense of the verb. Errors of English past tense morphology are a well-known feature in children's speech and this aspect of language is particularly vulnerable in children with language impairment. In this study, all groups produced some overregularizations (*he hitted*). However, SLI children gave more unmarked (*he walk*) or invalid responses than either their FL or TD peers. For the FL children, lesion side (left or right-hemisphere) mattered very little. However, children with left-hemisphere lesions tended to produce more unmarked verbs, similar to the strategy used by the SLI group. These data again suggest that brain plasticity plays a major role in language development for FL children.

Wulfeck, Bates, Krupa-Kwiatkowski, and Saltzman, examined grammatical sensitivity and processing times associated with the detection of grammatical errors in sentences in school-aged TD, SLI, and FL groups. Previous research has indicated that after initial delays in language development, FL children show remarkable progress during the school years. However, it has been less clear whether or not these children show more subtle language processing deficits. The results from grammaticality judgment reveal that all groups continue to develop grammatical sensitivity well into adolescence, although profiles differ. Compared to TD children, SLI children develop grammatical processing abilities at slower rates, whereas the FL children show remarkably good development of grammatical sensitivity. Findings suggest that the underlying mechanisms responsible for specific language impairment may be more pervasive and less flexible compared to the more plastic and resilient systems that operate in children with early brain injury.

Finally, in a study by Reilly et al., preschool and school-age FL, SLI, WMS, and TD groups describe the picture story, *Frog, where are you*? (Mayer, 1969). Narratives, which are common in children's speech, permit the assessment of a variety of linguistic features, from grammatical morphology and complex syntax to discourse coherence and cohesion. In this study, children with FL showed initial delay in narrative skills, but by age 7–8 they generally performed within the normal range. Children with SLI, who have no frank neurological damage and show no cognitive impairment, on the other hand, demonstrated significantly more delay on all morpho-syntactic measures than the FL group, and performed comparably to the WMS group on grammatical morphology. By the end of elementary school however, FL and SLI groups were telling as complete a narrative as their typically developing peers.

This issue closes with an overview and summary by Bates and a commentary from Holland. Together, both authors offer insights and raise intriguing questions concerning the complex picture of language development. Multiple lenses on brain-language relations emerge from our studies. For example, in the FL group, contrary to adult data, there were few site- or side-specific findings; in those studies that include FL and SLI children, a pattern emerges in which the children with frank neurological insults (FL) consistently perform better than their SLI age mates who show no frank damage. And with respect to verbal memory and morphosyntax, there are tantalizing similarities in the performance of the WMS group, who are mentally retarded, and in the SLI group who are not. Overall, these studies of language acquisition in atypically developing children help us to better understand the nature of language development, and the nature and extent of brain plasticity for language. Structurally and functionally, the neural organization of children from each of these groups differ. What we see in this issue is how each addresses the language learning problem. Our results suggest great flexibility in the resources one needs to acquire a language. Yet once a child has begun this process, there are clear constraints. All groups appear to be following similar developmental paths.

## Acknowledgments

The research reported here was supported in part by funding from NIH-NINDS Grant P50 NS22343 and NIDCD PO1 1289. We would like to express our gratitude to our colleagues, staff, and research assistants at the San Diego Project in Cognitive and Neural Development (PCND) for their contributions to these studies. A special thanks goes to our reviewers Audrey Holland and Dorothy Bishop and to Judi Fenson for assistance with proofing and final preparation of the manuscripts in this issue. Finally, we thank the wonderful children and families who have participated in these studies.

## References

Bates, E. *Explaining and interpreting deficits in language development across clinical groups*: Where do we go from here?

Holland, A. Commentary: B. Wulfeck, & J. Reilly (Eds.). *Plasticity and development: Language in atypical children*. Special Issue, *Brain and Language*.

Marchman, V., Saccuman, C., & Wulfeck, B. Productive use of the English past tense in children with focal brain injury and specific language impairment.

Mayer, M., 1969. *Frog, where are you?* Dial Press.

Nichols, S., Jones, W. Roman, M., Wulfeck, B. Delis, D. Reilly, J., Bellugi, U. Mechanisms of verbal memory impairment in four neurodevelopmental disorders.

Reilly, J., Losh, M., Bellugi, U. & Wulfeck, B. Frog, Where are you? Narratives in children with specific language impairment, early focal brain injury and Williams Syndrome.

Thal, D., Reilly, J., Seibert, L., Jeffries, R. & Fenson, J. Language development in children at risk for language impairment: Cross-population comparisons.

Weckerly, J., Wulfeck, B. & Reilly, J. The development of morpho-syntactic ability in atypical populations: The acquisition of tag questions in children with early focal lesions and children with specific language impairment.

Wulfeck, B., Bates, E., Krupa-Kwiatkowski, M. & Saltzman, D. Grammaticality sensitivity in children with early focal brain injury and children with specific language impairment.