SPEECH AND LANGUAGE

Lexical and grammatical development

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Significant progress is being made in understanding some of the main reasons why children with intellectual disabilities, and particularly children with Down syndrome, have major difficulties in developing accurate lexical repertoires and mastering basic grammatical structures in their maternal tongue. These reasons are identified and briefly discussed in the paper together with recommendations for future research.

I take as my starting point (with Macnamara and Bloom[1,2]) that lexical development or learning (whichever term one prefers) minimally implies:

(1) an ability to perceive speech and segment the discourse in (lexical) units,
(2) an ability to infer the meaning intentions of others,
(3) an ability to acquire concepts (assuming as I do that meaning exists cognitively and not just as a kind of stimulus meaning, i.e., a person's disposition to respond to certain sensory stimulation[3,4]),
(4) certain memory abilities, and
(5) specific articulatory abilities.

The two questions in keeping with the focus of this review are: "what do we know about these aspects regarding individuals with Down syndrome?" and "what does this suggest about which direction future research and intervention work should take?"

I shall leave speech perception to Michèle Pettinato and speech production and articulatory development to Pete Howell, Steve Davis, and Sara Wood, only to remark that the difficulties in these areas can be expected to influence lexical development and should be addressed in their own rights.

A poorly researched yet important point (for typically developing children as well as for infants with Down syndrome) is how children learn to segment speech flow into lexically relevant units. Some research work (e.g., REF 5) suggests that the first lexical acquisitions derive from the words more often used by the caregivers. Nothing is known for sure of the mechanisms involved which are based on, but go beyond, regular syllabic perception.

A common finding is the close relationship between mental age and receptive lexical development[6,7]. This relationship yields a way of assessing the conceptual aspects of lexical development, which can be further explored by looking at semantic strategies used in word learning[8,9]. What kind of concepts do children form when they are confronted with objects or events and hear a more mature speaker uttering a lexical label? Research suggests that they rely on a limited set of strategies whose origin is probably cognitive. These include: the whole object strategy (a new label refers to the entire object and not to any of its parts or properties), mutual exclusivity (to each object category corresponds a given label), conventionality (names have conventional meaning stable over time), novel name-nameless category (a new label refers to a category that does not have a label yet). Work conducted with children with intellectual disabilities (including children with Down syndrome) show that possessing some of these strategies correlates with faster lexical development[10,11]. Assuming that there is more there than a simple coincidence in time, one might consider systematically training the child with intellectual disabilities towards understanding and using such strategies in a plausible attempt to boost early lexical development.

As Bloom insists, semantic learning also implies deciphering in some relevant way the mind of the social partner whenever s(he) utters a new word; concretely using inferences about the referential intentions of the partners to create pointers from words to world entities[2]. Typically developing children draw on their understanding of the thoughts of others - on their 'theory of mind' (TOM) – to learn the objects and events to which words refer, how words relate to one another, and understand how they are used as signs with pragmatic value. We know very little on these developmental aspects in children with intellectual disabilities and next to nothing in children with Down syndrome. As a general guideline, the extent of the semantic deficit found in autistic children seems to be a direct function of the severity of their TOM deficit[12]. Given that TOM has a cognitive component (besides perhaps a specific and possibly modular one; cf. the arguments in REF 13), one should expect difficulties in this respect with children with intellectual disabilities but their impact on lexical retardation is unknown at the present time.

A minimal short-term or working-memory ability is obviously involved in any lexical learning. The longer a given label can be maintained in working memory, the greater the likelihood that it will be learned (i.e. stored in long-term memory). Children with Down syndrome show deficits in the development of auditory-verbal working memory, partly because of a limited capacity system and a deficiency in their phonological loop, a key dimension of the working memory system according to Baddeley's theory[15-19]. Attempts to improve working memory development and to extend the typical working memory span in children with intellectual disability have been relatively successful (see REF 20 for a review). More research should be devoted towards understanding the basic limitations and improving the technology used in intervention regarding this central aspect of cognitive development in Down syndrome.

Lexical organisation in long term memory should not be left aside. Lexical production and comprehension require quick and reliable retrieval from semantic memory. This depends on the organisation of semantic storage. Few systematic studies have been conducted on these aspects of cognitive functioning in Down syndrome. Some information is available, primarily concerning subjects with mild intellectual disability (see REF 6 for a review). This suggests the existence of similar storage strategies as those documented in typically developing children commensurate with growth in mental age (e.g., prototypicality and gradual extension towards less prototypical entities in lexical categories, vertical hierarchies in three or more levels: basic – dominating for a long developmental time, subordinate, and superordinate). We need corresponding data to intervene more efficiently on these aspects of lexical functioning in children with Down syndrome.

Grammatical learning

I take grammar to mean the subsystem establishing a systematic correspondence between relational semantics (the network of meaning relations needing sequences of words to be expressed properly) and morphosyntax. Development in this area for typically developing children or children with intellectual disabilities encompasses four dimensions: (1) a proper input from which to proceed, (2) cognitive development to rely on, (3) a particular driving device to insure learning, and (4) devoted brain mechanisms.

Relational semantic development (i.e., the embodiment of such relationships as presence, absence, return, qualitative and quantitative attribution, possession, localisation, accompaniment, transitivity, etc.) goes hand in hand with cognitive development, which should be expected given that the former is the linguistic interface with cognition. By definition no genuine grammatical development can take place until the semantic basis is well underway.

Early work demonstrated that the language input to children with Down syndrome is adapted to their level of development and becomes gradually more complex with the progress they exhibit in their speech and understanding. A recent update confirms this normative indication[21]. If the linguistic environment of the child with Down syndrome is not problematic, how can his/her language difficulties be explained? This brings us to points 2 and 3 above. Quite clearly, the cognitive delays and difficulties (knowledge deficiencies, memory limitations, etc.) play a role (e.g., REF 22). It is likely, however, that other factors, more specifically related to linguistic processing and learning need to be considered. A supportive argument is the observation that the difficulties documented in language development differ in some ways in various genetic syndromes of intellectual disability at corresponding global levels of cognitive retardation (Down syndrome, Williams syndrome, Fragile X, Noonan syndrome, Prader-Willi syndrome, etc.; see REF 23 for an analysis). Additionally, the relatively large inter-individual variability within intellectual disability syndromes also undermines any attempt at explaining the developmental variance only or mostly in cognitive terms[24]. Which are the more specifically linguistic aspects one needs to consider? Given that language development in children with Down syndrome is but a delayed and incomplete version of typical development, the same underlying processes can be posited in both cases beyond the observation that the sequences of developmental steps within each major language component are similar[25]. What are these processes? This question lies at the heart of one of the major and long lasting debates in developmental psycholinguistics.

Is there a strong genetic predisposition to grammatical development and, if yes, what does it consist of? What kind of learning is involved? The problem carries decisive implications for training in intellectual disabilities, for as long as the exact nature of grammar development is not clarified one cannot be sure of the way to go in planning efficient interventions.

Chomskyan types of ideas concerning formal and/or functional grammatical categories (so-called representational nativism[26]) are less accepted today in the sense that their supposed genetic origins remain as mysterious as they were years ago when first proposed[27,28]. However, they cannot be completely ruled out for lack of decisive experimental evidence. A number of indications go against such a view, for example, the insufficient coding power of the genotype regarding the posited grammatical phenotype[29] and, more germane to the present discussion, the fact that the cognitive and language problems in the intellectual disability genetic syndromes correspond aetiologically to a large number of chromosomes (from chromosome 5 in Cri-du-chat syndrome, chromosome 7 in Williams syndrome, chromosome 12 in Noonan syndrome, chromosome 15 in Prader-Willi and Angelman syndromes, chromosome 17 in Neurofibromatosis type 1, chromosome 16 in Rubinstein-Taybi syndrome, chromosome 21 in Down syndrome, and the several conditions linked to the X chromosome; see REFS 23,30,31). If there were a grammatical representational basis existing genetically prior to language experience that would be damaged in intellectual disability , it would have to coexist in a large number of chromosomes which makes the coding power indication of Elman et al.[29] even more damaging for the representational nativist hypothesis.

Contrasting models which have been empirically validated exist under the banner of connectionism, suggesting that it is possible to dispense with formal rules and linguistic representations in language development and functioning. The most relevant paradigm for language acquisition in this latter perspective may be implicit learning (plus procedural memory); a paradigm first explored by Reber[32] and rejuvenated in recent years to accommodate a large number of cognitive and language facts regarding development and pathologies[28,33]). It may be considered that devoted and highly specialised brain areas operational from the start (organic or neurological nativism) are the real operators of language and grammatical construction exploiting the many associative regularities and stochastic information present in the thousands of properly adapted utterances addressed year after year to the language-learning child by the social environment. A clear sensitivity to the stochastic properties of the language input has been demonstrated in young children (e.g., REFS 34,35,36). There is no reason to believe that it ceases to operate after the first few years. Reviews of studies on the heritability of language (twin, adoption and linkage studies; e.g., REF 37), sometimes interpreted as supporting representational nativism, are actually perfectly compatible with neuro-

logical nativism (even more to the extent that they reveal a similar genetic basis for some familial oral and primary written language pathologies).

The language problems in intellectual disability may arise from an insufficient development of some or all of the devoted brain language areas, depending on the syndrome and its aetiology, complicated in some cases by anomalous patterns of cerebral specialisation (particularly for speech perception; see REFS 24,38,39). Problems in the areas responsible for speech processing negatively interact with major insufficiency in attention and memory, also genetically motivated. The brain differences in Down syndrome are beginning to be better known[40] and systematic investigation in the same respect has started for other intellectual disability genetic syndromes. They are yielding results supporting the hypothesis of a deterministic relationship between particular genotypes and neurobehavioural characteristics (see REF 41).

The overall intervention objectives are clear if not necessarily easy to implement. They command:

(1) speeding up relational semantic development (implying that some level of lexical development has been reached) which means working specifically on the interface between cognitive and semantic representations;

(2) systematically improving the memory capacities of children with Down syndrome as early as possible (working memory overall but also longer-term storage and organisation to insure better and quicker access to learned information);

(3) providing and properly organising as many opportunities as possible for associative and stochastic morphosyntactic learning in pragmatically motivated utterances;

(4) advancing as far as possible along that way, taking into account the substantial inter-individual variability.

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