



# Language acquisition as skill learning

Nick Chater<sup>1</sup> and Morten H Christiansen<sup>2,3,4</sup>

Language acquisition researchers have often viewed children as ‘mini-linguists,’ attempting to infer abstract knowledge of language from exposure to their native language. From this perspective, the challenge of acquisition can seem so formidable that meeting it would appear to require that much of this knowledge must be built-in, as a language instinct or universal grammar. From this viewpoint, language acquisition is also disconnected from language processing, and from the acquisition of other learned perceptuo-motor or cognitive abilities. This paper explores a recent alternative viewpoint, the ‘language-as-skill’ framework, according to which the child’s challenge is practical, not theoretical: the child learns to understand and produce the language from practicing conversational interactions. Language acquisition can thus be seen as a type of skill acquisition, using similar mechanisms to those involved in learning to ride a bicycle, play a musical instrument, or draw a picture; and the need to acquire knowledge of the abstract structure of language is dissolved. This perspective takes the pressure off biological adaptation as the primary driver of language evolution, emphasizing instead the cultural evolution of linguistic structure.

## Addresses

<sup>1</sup> Behavioural Science Group, Warwick Business School, University of Warwick, Coventry CV4 7AL, UK

<sup>2</sup> Department of Psychology, Cornell University, Ithaca, NY 14853, USA

<sup>3</sup> The Interacting Minds Centre and School of Communication and Culture, Aarhus University, 8000 Aarhus C, Denmark

<sup>4</sup> Haskins Laboratories, New Haven, CT 06511, USA

Corresponding author: Chater, Nick ([Nick.Chater@wbs.ac.uk](mailto:Nick.Chater@wbs.ac.uk))

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Each of us spends a large fraction of our waking lives both producing and understanding language. Moreover, language processing requires acquiring a spectacular variety of skills, from the low-level mechanisms required to process relevant complex acoustic and/or visual input and create the articulatory gestures involved in producing speech of one’s own, to the ability to deal simultaneously with multiple layers of linguistic structure (e.g. phonetics,

phonemes, morphemes, syntax, semantics and pragmatics). Learning to express ourselves and interpret the communicative intentions of others through the tool of language is one of the major challenges facing the developing child.

It seems natural to view our remarkable ability to acquire language as a challenge of skill learning, alongside learning to ride a bicycle, to draw, learning a style of dance, or to play a musical instrument. The challenge of learning a language is merely more multifaceted and complex. Yet for decades, many influential linguists and language acquisition researchers have argued that acquiring a language is not primarily a matter of learning a skill (e.g. [1–3]). Instead, they view the challenge of acquisition not as a practical problem of learning how to use language effectively in, for example, everyday social interactions, but rather as a theoretical problem: to infer the grammar of the language from the available linguistic input that the child encounters from speakers of that language. The child is viewed as a ‘mini-linguist,’ attempting to piece together the correct grammar of the language to which she is exposed, by careful analysis of the available linguistic data. This presumed linguistic ‘competence’ is supposed to correspond to an abstract knowledge of the language; and the task of using this competence to conduct communicative exchanges is viewed as of secondary importance, a matter of ‘mere’ performance [1]. From this *language-as-knowledge* perspective, learning a language is primarily a theoretical enterprise rather than a form of skill acquisition [4].

Recent developments across the language sciences strongly favor, we argue, a return to the intuitive *language-as-skill*, rather than the language-as-knowledge, viewpoint. Moreover, seeing language learning as continuous with other types of cognitive skills helps explain how language acquisition is possible in the first place — from both a developmental and evolutionary standpoint — and allows a reintegration of the language sciences.

## The Now-or-Never bottleneck

Whether playing a piano duet, driving a car, playing soccer, or engaging in conversation, our brain must process and react rapidly to a continuous flow of information. But how is this possible, given the fleeting character of memory? Indeed, basic auditory [5,6] and visual [7] information appears typically to be lost within 50–100 ms. Yet in a typical perceptuo-motor skill, we are faced with an onrushing stream of sensory information, where new information rapidly obliterates the old; and often we must generate a continuous stream of motor

commands, such that each command must be implemented before it is overwritten by the next. Unless the information is used or recoded right away, it will be lost forever. How is the brain able to overcome this ‘Now-or-Never Bottleneck’ [8\*]?

We suggest that human skill learning requires learning to recode and compress complex time-varying input into successively larger and more abstract representations: low-level visual input is translated into sequences of actions and events; streams of sound are recoded into notes, musical phrases, and tunes; speech is recoded, moment-by-moment, into phonemes, words and morphemes, multi-word constructions, and so on. We call this aspect of skilled perception *Chunk-and-Pass processing*: material at each level is immediately compressed and passed onto a more abstract level of representation; this more abstract representation is itself compressed and passed to a higher-level representation still, and so on. Although this chunking process is ‘lossy’ (in that only some information is passed on), the resulting representations are also enriched with top-down information from distributional, semantic and pragmatic expectations. Similarly, streams of motor commands must be implemented right away, or they too will be obliterated by later commands. The cascade of levels here is reversed: high level planning (which pass to make in soccer, which tune to begin playing, which message to convey) is recoded in successively more specific commands, which are implemented right away. We call this aspect of skilled action *Just-in-Time* processing: high-level representations are ‘unpacked’ into streams of lower-level detailed motor plans, which must be implemented immediately, before they are overwritten by the onslaught of later commands.

The intertwining of Chunk-and-Pass perception and Just-in-Time production is particularly intricate in skills involving joint action, such as playing musical duets, partner dancing and team sports, in which two or more people must continually mutually adjust their actions, in the moment, to align with the actions of others. Recent work has suggested that conversational interchanges have this character: turn-taking is often so rapid that partners not only must predict what the other will say but also simultaneously plan their own conversational contribution — all before the speaker finishes talking [9\*].

### Language acquisition as skill learning

Theories of skill learning typically see skills as drawing on highly localized packets of information: for example, production rules [10,11] encoding specific snippets of information, or stores of past processing episodes, which can be retrieved and reused (e.g. [12]). This perspective does not fit well with knowledge-based views of language — such approaches view the knowledge of language as forming an intricate and integral idealized competence, rather than a collection of local procedures for

action. However, these theories of skill learning fit well with recent usage-based theories of language (such as construction grammar, e.g. [13]), which sees the grammar as a collection of *constructions*: local mappings between sound and meaning, which can be acquired one-by-one through experience in language processing. Indeed, such constructions can be viewed not as encoding abstract knowledge, but as procedures for translating sounds into meanings and back: that is, grammar is seen as providing the building blocks of skilled language use [14,15].

The language-as-skill viewpoint helps resolve one of the classic puzzles of the language-as-knowledge approach: how language is learnable without relying on ‘negative’ evidence. According to the language-as-knowledge view, a learner may propose a grammar that includes sentences that are not actually allowed. It turns out, though, that care-givers rarely correct children’s errors, and where corrections are available, they are typically ignored. This has raised the puzzle concerning how children can ‘recover’ from overgeneralizations without such negative evidence, a problem so severe that it has been termed the logical problem of language acquisition [16]. Within the language-as-knowledge perspective, this problem can be addressed in a number of ways (e.g. [17,18]). But from the language-as-skill viewpoint, the problem does not arise in the first place: the child is not learning a *theory* of which sentences are allowed, but *building up a set of procedures* for understanding and producing language. In skill learning, ‘pure’ negative feedback is rarely informative. Being told that one’s singing, dancing or driving is ‘wrong’ is unhelpful — what is needed, instead, is a demonstration of what correct performance would look like. Indeed, this is just what caregivers tend to do in response to linguistic errors: they reformulate what they believe the child is intending to say [19]. Being able to process such reformulations requires mapping between observed behavior and one’s own behavior. Within language, as with perceptuo-motor skill more generally [20], there is considerable evidence that the representations underlying the perception and generation of actions are closely related (e.g. [21]), allowing such learning to occur fluently [4].

More broadly, the language-as-skill perspective naturally explains the conservative nature of children’s linguistic development: rather than making bold conjectures about the nature of language, the child’s utterances initially stick closely to the linguistic input to which she has been exposed — what the linguist Culicover [22] calls ‘conservative attentive learning.’ Analysis of care-giver and child speech shows that children initially reproduce and adapt specific linguistic constructions often linked with specific lexical items [23] such as ‘I like \_\_\_’ (from *I like milk, I like water*, etc.) and ‘I wanna \_\_\_’ (from *I wanna see, I wanna eat*, etc.), where the ‘slots’ are filled with gradually broadening sets of nouns and verbs, respectively [24\*]. From a language-as-skill perspective, we can

view the child as gradually accumulating a richer set of linguistic constructions, where each construction is viewed not as an abstract conjecture about language structure, but as a procedure for mapping between sound and meaning [8\*].

### The role of experience

Successful skill learning requires practice and, ideally, practice on successively more challenging variants of the skill. Learning to ride a bicycle, dance or play the piano involves starting with simple versions of the task, specifically tailored for the learner; and gradually increasing the level of complexity. Language skills are no different: children typically learn conversational interaction through huge numbers of communicative exchanges with caregivers and siblings. Through such repeated interactions, children hone their Chunk-and-Pass perception and Just-in-Time production skills, thereby improving their ability to comprehend and produce language in the here and now. Studies measuring how quickly two-year-olds can process auditory input (e.g. *Look at the doggy*) and look at the appropriate picture (a dog versus a car) have shown that the speed with which they process the input is predictive of their expressive language skills up to eight years of age [25]. However, these improvements in language ability are not driven by raw input alone but rather, by the number of engaged interactions due to the fundamental turn-taking nature of everyday conversations. Indeed, caregivers often appear to adapt the linguistic and social input to the child to support learning (e.g. [26]). Thus, the sheer amount and richness of conversational interaction is a good predictor of linguistic development, and appears to be the crucial mediator in links between language ability and socio-economic status [27\*].

As with other skills, language learning continues throughout the life-span: we are continually acquiring new names, technical terms, idioms, and even shifting our speech patterns and use of syntactic constructions [28]. Similar to other skills, learning language early in life is often beneficial; but the same acquisition mechanisms can be applied in second language learning — although second language acquisition is often built on foundations learned from the first language which may leave traces, for example, in specific processing patterns that may not work well for the second language [29]. From this point of view, the impact of a first language on how a second language is acquired and spoken is a natural consequence of the processes of skill acquisition — just as years of learning a particular musical or dance style will leave traces when we later switch to some other style. The fact that learners of a second language may never become indistinguishable from first language learners does not, then, require postulating the existence of a critical period for language acquisition, as has previously been conjectured (e.g. [30]).

### Reintegrating the language sciences

The language-as-knowledge viewpoint sees language acquisition as profoundly distinct from skill learning in general. Viewing the child as a mini-linguist, who is attempting to formulate an adequate theory of the language from the linguistic data she encounters, makes the challenge of acquisition seem so formidable that many theorists have assumed that little learning is possible. Instead, language acquisition is viewed as the unfolding and fine-tuning of an innate universal grammar. The language-as-skill perspective, by contrast, sees the child's challenge as practical, not theoretical: her goal is to acquire a set of procedures that allow her to communicate effectively. From this viewpoint, language is reconnected to basic psychological mechanisms of learning and processing. This opens up the possibility that general principles of cognition can inform the language sciences: the structure of language may, for example, be viewed as analogous to the structure of human action; common memory and processing restrictions across individuals will be expected to govern linguistic and non-linguistic tasks [31]; and the world's languages can be seen as cultural evolved systems shaped by the brain's ability to learn, generate and process sequential material [28].

### Conflict of interest statement

Nothing declared.

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The paper argues that a memory-based 'bottleneck' forces language to have a local structure; that the flow of incoming linguistic material must be chunked immediately and passed to a higher representational level (Chunk-and-Pass processing); and that language production involves the reverse process, using a hierarchical cascade of representations, each of which must be 'unpacked' into a lower level form and implemented immediately, to avoid being overwritten by later material (Just-in-Time production). The viewpoint places strong constraints on theories of language processing, acquisition and change.

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This paper explores the implications of the astonishing fluency and speed of turn-taking in dialogue. Gaps between conversational turns are typically around 250 ms, whereas preparing word or utterance in isolated speech is considerably slower. This is only possible given that incoming linguistic information is being analyzed and interpreted incrementally (including pragmatic analysis); and that comprehension and production processes must heavily overlap. It is argued that the requirement that language be predictable may place some constraints on language diversity; and that turn-taking has deep developmental (i.e. in pre-linguistic infants) and evolutionary roots (rapid vocal turn-taking is observed in other primate species).

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Analysis of corpora of child speech reveals it to be based on local structural patterns, based around specific verbs. The flexibility with which different nouns can be 'slotted in' to the frame 'I want\_\_' (e.g. *I want cake, I want some, I want cake*, etc.) is restricted, and verb-specific. Young children appear to be repeating and gradually varying specific utterances, and building up greater linguistic 'productivity' gradually, rather than forming linguistic generalizations over abstract grammatical categories (Noun Transitive-Verb Noun).

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Previous studies have shown a correlation between social-economic status, amount of input and vocabulary size, with lower SES associated with less input and poorer vocabulary skills. Using in-home recordings, the authors showed that the amount of engaged interaction between caregiver and child predicted vocabulary skills independent of SES and raw input. Importantly, the authors argued that this relationship was mediated by language processing efficiency (measured by the proportion of the time infants looked at a named target rather than a distractor). Thus, the authors argued language processing efficiency is enhanced by direct interactions between child and caregiver (e.g. book sharing, playing, etc.), rather than the mere presence of speech in the background; and improved processing speed in turn enhances vocabulary skills.

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