

## From Rousseau to Suppes. On Diaries and Probabilistic Grammars

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Jean-Jacques Rousseau was born in 1712, three centuries ago. This year (2012) we also celebrate the 250<sup>th</sup> anniversary of his book *Émile ou de l'éducation* of 1762. Although Rousseau was an almost exact contemporary of David Hume, the *Émile* was not an Enlightenment treatise, but in fact an early Romantic one. Not rationality, but nature should be our lead in creating a society in which the Enlightenment virtues of human goodness, freedom and equality will prosper. With the *Émile*, Rousseau intended to revolutionize educational practice. It is nature, not human drill, by which the child should be educated. A first requirement to make this work is for teachers to carefully observe their children: "Hence, begin by better studying your pupils, because surely you don't know them at all" (Rousseau (1762, p. 3)). It is a condition for a natural education of the child. And that was certainly a tough type of education: "Observe nature, follow the route that it traces for you. Nature exercises children continually, it hardens their temperament by all kinds of difficulties, it teaches them early the meaning of pain and sorrow." (p. 65); "Accustom them therefore to the hardships they will have to face; train them to endure extremes of temperature, climate, and condition, hunger, thirst, and weariness." (p. 66). (All children Rousseau fathered himself were dropped in children's homes, completely deserted by Jean-Jacques).

Although Rousseau's own observations on children's development were rather limited, many pedagogues took his advice seriously and began collecting observations on children's development, including language development. Rousseau's theories became especially influential in German pedagogical circles. Educational practice should turn back to nature became the new principle. Joachim Heinrich Campe, enlightened theologian and pedagogue in Hamburg, organized a "Society of Practical Pedagogues" who jointly published, in the period from 1785 to 1793, a "General Revision" of the educational system in 16 volumes.

In his preface, Campe pleaded for well-off philanthropists to make available a thousand thaler for a competition on diary writing. Such a diary on "the bodily and mental changes of a child" from birth would "indescribably" enrich our knowledge of the growing-

up child. (Campe (1785-1792, pp. xxiv-xxv)). There is no evidence that Campe's competition materialized, but a few attempts in diary writing followed his plea.

Dietrich Tiedemann, a philosopher, had kept his diary from 1781 to 1784 and published it in 1787. It contains, well-counted, 15 observations on son Friedrich's speech during the 30 month observation period since birth. Around 7 months, for instance, Friedrich began to imitate spoken sounds, such as *ma*. At 8 months he would point to X when asked "where is X?" At 19 months he would produce a variety of words, but the productions were monosyllabic, usually the word's last or stressed syllable. At 21 months the first sentences appeared, mostly combining an infinitive verb and a nominal noun; there were no inflections or articles.

Only one year later, mathematician Moritz Adolph von Winterfeld, heavily inspired by Rousseau, published another diary. It announced to relate the "the gradual formation of the quite peculiar language, the very simple children's grammar." (von Winterfeld (1789, 1791, p. 405)). However, it mostly concerns the bodily development of daughter Amalie Louise (born January 13, 1785), far less her mental development. As for linguistic observations, there is mention of a few first words, there is mention of the impossibility to pronounce *h*, "although this is one of the easiest letters", and there is mention of a first negation, *nicht* all at 32 months. That is all. But Winterfeld was certainly enlightened. He inoculated his child with his own hands with the puss of cow's smallpox. The child got very ill, but then survived the following smallpox epidemic.

A second small wave of diary keeping emerged around the midst of the 19<sup>th</sup> century. Four diaries survive from that period (by Goltz, Löbisch, Eschericht and Sigismund). Most extensive and most cited became the 1856 monograph by Berthold Sigismund, a family doctor and teacher in Rudolfstadt. Sigismund dedicated some 50 quite perceptive pages to language acquisition in the second year of life. Linguistic observations on the first year are few, and for us remarkable for their underestimation of the child's capacities. I will not go over much interesting detail, but just mention two important theoretical claims, that would play a long-lasting role in language acquisition research. The first one is Sigismund's claim about the function of all first words:

"That the little speaker uses the first uttered words at once, mainly or maybe exclusively, as expressions of will", "The protolanguage is nothing but a will made audible." (pp. 112-113)

This idea would be picked up, almost half a century later by Wundt's student Meumann and then became canonical in the literature. The second one concerns the child's early phonology. It is the notion of 'least effort'. Easy speech sounds, such as *b* and *m*, *n*, *d*, and *s*, come before the harder ones, such as *g*, *w*, followed by *f*, *ch*, *k*, with *l*, and *sch*, with *r* closing the ranks. This 'least effort' notion was going to play a major role in evolutionary explanations.

All in all, however, in mid-19<sup>th</sup> century, diary making had lost its intellectual appeal. All diary keepers were isolated teachers without any link to science or academic circles. That changed drastically 30 years later, in 1886/87. Then, what had been no more than marginal, scattered business, was suddenly drawn into an explosive scientific development. The French man of letters Hippolyte Taine provided the fuse and Charles Darwin set fire to it. In 1876 Taine had published a report of the diary notes he had made on his infant daughter's language development, a report making ample reference to evolution theory:

“Speaking generally, the child presents in a passing state the mental characteristics that are found in a fixed state in primitive civilizations, very much as the human embryo presents in a passing state the physical characteristics that are found in a fixed state in the classes of inferior animals.” (p. 259)

The next year the new journal *Mind* published an English translation thereof. This triggered Charles Darwin to publish, in the same year 1877 and the same journal, a 10-page *Biographical sketch* of his own son William’s development as an infant. The sketch was based on copious notes Darwin had made between 1839 (upon William’s birth) and 1841. Clearly, after reading Taine’s paper, Darwin didn’t want to repeat the Wallace affair. He had been the first to keep a diary, over 30 years before Taine, and the world should know. Celebrity Darwin’s paper appeared the same year also in French, German and Russian, not failing to promote the diary business on a grand scale. From now on, keeping diaries on child development was real science. A tsunami of diary keeping emerged, which reverberates till the present day.

Darwin’s sketch includes some observations on the development of William’s language skills, hardly more than the 15 observations Tiedemann had provided almost a century earlier and substantially less than Sigismund’s extensive records. Darwin stressed in particular the invention of first words, such as *mum* to express the wish for food. He also noticed the “instinctive” use of intonation patterns, “voice modulation”, to express various modes, such as interrogation and exclamation. Here he concluded, repeating what he expressed in *The Descent of Man*, that “before man used articulate language, he uttered notes in a true musical scale” (p. 293), the singing origins of language, which never stopped echoing in the literature. The importance of Darwin’s paper was not so much in its content. But in one swoop it made the study of child development a respectable branch of human biology. Diaries now appeared at an accelerated rate, and in various languages, see Table 1. My book on the history of psycholinguistics (Levelt (2013)) provides much detail on the history of child language diaries.

TABLE 1 Nineteenth century diaries

Goltz (1847), German	Sayce (1889), Arabic
Löbisch (1851), German	Chamberlain (1890), Algonkin
Eschericht (1852), German	Gabriel Deville (1890/91), French
Sigismund (1853), German	Garbini (1892), Italian
Baudouin de Courtenay (1869), Polish	Compayré (1893), French
Taine (1876, 1877), French	Balassa (1893), Hungarian
Darwin (1877), English	Frederic Tracy (1894), English
Perez (1878, 1886), French	Paola Lombroso (1894), Italian
Strümpell (1880), German	Preyer (1896), German
Sikorsky (1883), Russian	Kathreen Moore (1896), English
Blagovescenskij (1886), Russian	Milicent Washburn (1898), English
Machado y Álvarez (1885–1887), Spanish	Ament (1899), German

It is from these early diaries that the first child language statistics was derived. Doran (1907) was the first to publish an overall statistics on vocabulary size (based on over 100 children), see Fig. 1.

This diary industry continued all over the 20<sup>th</sup> century. Table 2 presents an overview of 20<sup>th</sup> century diaries before 1960. Here Clara and William Stern’s 1907 extensive study

VOCABULARIES OF CHILDREN.

TABLE I.

Vocabularies of Children.

Age.		Number of Words, and Reference.										Av.	Notes.
Month.	No.	Ref.	No.	Ref.	No.	Ref.	No.	Ref.	No.	Ref.			
8	1	31										1	a. All references
9	1	31										5	(1) indicate the same
10	3	51	9	107			1	40b				5.3	child at that age.
11	12	51										12	b. All references
12	4	707		8	107	10	40	17	30	200	107	13.8	(1) refer to one of
		24	51										three children in the
13	22	40	38	51								15	same family at differ-
14	50	40	58	51								14	ent ages, shown sepa-
15	4	40	62	44	73	40	106	51				61.3	rately in Yabraft and
16	9	40	82	40	199	51						99	lit.
17	18	40	18	107	151	40	212	51				109	c. Exact age un-
18	33	40	74	110	80	44	113	40	144	30		112.8	certain.
		233	40										d. For the record
19	81	40	178	30	144	107	281	40				145.7	of Vivia Otlet's, "the
20	204	40	374	40								289	baby school," see p.
21	177	107	360	40	579	40						375	104.
22	28	107	62	107	377	40	465	40	665	40		390.8	e. Free. E. D. Mur-
23	136	107	489	40	612	40	710	40				426.7	RAYB.
		10	101	36	107	50	81	115	42	139	107		f. Estimated.
24	172	56	382	107	397	82	399	56	4000	41		453.3	
		483	58	578	42	514	42	729	40	742	40		
		781	40	1050	41	1131	58	d					
25	250	107	822	40								541	
26	921	40										923	
27	171	107	1012	40	1079	40						700.2	
28	451	107	667	107								539	
29	1187	40										1187	
30	327	107	480	110	629	41	731	41	769	41		869.8	
		1090	44	1412	40	1519	40						
31	642	88										642	
32	1176	42										1176	
33	839	44										837	
34	1009	44										1009	
35	830	e	1600	42	1600	107						1399.2	
36	1528	88	1528	53								1528.5	
37	960	e	3000	781								1480	

FIGURE 1 Doran's (1907) child vocabulary statistics

set the new standards for the decades to come. They reported in much detail on the language development of their three children Hilde, Günther and Eva. Vocabulary development is only one aspect of this study. A major part of the book is dedicated to syntactic development. In the decades to follow, a rich statistics was collected on syntactic complexity, from mere utterance length to the variety of syntactic types, coordination and subordination.

When famous, but Jewish William Stern was dismissed from his Hamburg professorship in 1933, Clara and William moved to Duke University, where William died in 1938. Clara died in 1945 in New York. Their former student Gordon Allport took care that the diaries, the largest ever created, were deposited in the Widener library. However, nobody showed any interest in them. Youngest daughter Eva then moved them to Hebrew University. With Eva's help we transcribed the full diaries at my Max Planck Institute and made them digitally available to the world, then the largest corpus of German language acquisition data.<sup>1</sup>

<sup>1</sup><http://www.mpi.nl/resources/data/stern-diaries>

TABLE 2 Twentieth century diary studies before 1960

Clara & William Stern (1907), German	Grégoire (1937, 1947), French
O'Shea (1907), English	Wawroska (1938), Polish
Gheorgov (1908, 1910), Bulgarian	Velten (1943), English
Ronjat (1913), French, German	Frontali (1943, 1944), Italian
Pavlovitsch (1920), Serbian	Gvozdev (1948, 1949), Russian
Bolin & Bolin, Swedish	Skorupka (1949), Polish
Jespersen (1916), Danish	Leopold (1939, 1949), English, German
Van Ginneken (1917), Dutch	Chao (1951), Cantonese
Kenyeres (1926), Hungarian	Cohen (1952), French
David & Rosa Katz (1928), German	Kaczmarek (1953), Polish
Ohwaki (1933), Japanese	Burling (1959), Garo
Lewis (1936), English	Bar-Adon (1959), Hebrew

The intellectual break with the rich German tradition was complete after the war. Roger Brown doesn't even mention the Sterns' monumental work in his famous 1973 book *A first language*, to which I will return below.

But first I should commemorate another occasion, dear to me. Four decades ago, in 1972, a few months after his 50<sup>th</sup> birthday, Patrick Suppes lectured in a NUFFIC summer course, which my former supervisor John van de Geer had organized in The Hague. I was on the organizing committee and Professor Suppes lectured on formal grammars and automata. I had just returned from the Institute for Advanced Study in Princeton (I will be eternally grateful to Duncan Luce who had invited me there). During the year I had written my treatise on formal grammars (Levelt (1974)), so I was all tuned in for Professor Suppes' course. One thing he discussed was his work on probabilistic grammars. In my book I had included a chapter on probabilistic grammars and further chapters on their (potential) application in linguistics and psycholinguistics. In the dominant Chomskyan linguistic community of the time, this was absolutely not done. This is what Chomsky himself had to say about it:

"It must be recognized that the notion 'probability of a sentence' is an entirely useless one, under any known interpretation of this term. On empirical grounds, the probability of my producing some given sentence of English -- say, this sentence, or the sentence "birds fly" or "Tuesday follows Monday" , or whatever -- is indistinguishable from the probability of my producing a given sentence of Japanese." (Chomsky 1969, p. 57)

Patrick Suppes not only pertinently and repeatedly argued against that curious position, but also set the example. In the early 1970s he and his research team were the first to do serious work on probabilistic grammars for early children's speech. It was the only empirical work on probabilistic grammars available when I wrote my book. Patrick Suppes' first applications were to the Adam corpus of utterances, collected by Roger Brown and co-workers, on which *A first language* is partly based. Brown had, unknowingly, continued the work by the Sterns, in particular their work on syntactic and semantic development.

The classic contribution Patrick Suppes (Suppes 1970b,a, 1971a,b; Suppes and Feldman 1971; Suppes 1974; Léveillé and Suppes 1976; Suppes 1976b,a; Suppes and Macken 1978) made to the study of language acquisition was two-pronged. He was the first to construct probabilistic grammars for a range of child language corpora. Not only Adam's corpus, but also corpora collected by his own team (especially Madeleine Léveillé and

TABLE I  
Probabilistic Noun-Phrase Grammar for Adam I

Production Rule	Probability	Noun phrase	Observed frequency	Theoretical frequency
1. NP → N	$a_1$	N	1445	1555.6
2. NP → AdjP	$a_2$	P	388	350.1
3. NP → AdjP + N	$a_3$	NN	231	113.7
4. NP → Pro	$a_4$	AN	135	114.0
5. NP → NP + NP	$a_5$	A	114	121.3
6. AdjP → AdjP + Adj	$b_1$	PN	31	25.6
7. AdjP → Adj	$b_2$	NA	19	8.9
		NNN	12	8.3
		AA	10	7.1
		NAN	8	8.3
		AP	6	2.0
		PPN	6	.4
		ANN	5	8.3
		AAN	4	6.6
		PA	4	2.0
		ANA	3	.7
		APN	3	.1
		AAA	2	.4
		APA	2	.0
		NPP	2	.4
		PAA	2	.1
		PAN	2	1.9

  

Estimated Parameter Values	
$a_1 = .6391$	$b_1 = .0581$
$a_2 = .0529$	$b_2 = .9419$
$a_3 = .0497$	
$a_4 = .1439$	
$a_5 = .1144$	

FIGURE 2 The very first probabilistic grammar for a child language corpus. The noun phrase grammar for the Adam I corpus, (From Suppes (1973))

Robert Smith (Suppes et al. 1974) such as Nina's corpus (23–39 months), 102.230 tokens, Philippe's French corpus (25–39 months), 56.982 tokens, Erica's corpus and a small Chinese corpus.

Figure 2 depicts the very first probabilistic grammar for Adam's corpus. It was only the beginning. When you read all subsequent papers, you get impressed not only by the sheer amount of detailed work, but by the enormous constraints imposed by the probabilistic paradigm on feasible syntactic rules. Rules that seem obvious to the ordinary linguist just do not work, whereas others that are considered trivial explain large degrees of variance.

The second important innovation Suppes introduced was to supply these grammars with a compositional, model-theoretic semantics (Fig. 3). That was the other thing not done in the Chomskyan linguistics of the day. Syntax was the thing, semantics was eschewed. Suppes supplied each syntactic production rule with a semantic function (such as identity, intersection, intensification, etc). These functions then combined, following the syntax, to compose the meaning of the noun phrase as a whole. And again, the experience was that these semantic functions put further constraints on what could be a possible grammar for the corpus.

To conclude, the aim of this paper was to acknowledge the important innovative twist Patrick Suppes gave to the now 250 year old tradition (since Rousseau's *Emile*) of collecting data on children's spontaneous speech. It was the introduction of probabilistic grammars and semantics to full corpora of children's speech. This innovation went much against the current in the linguistics of the late 1960s and early 1970s. Indeed, it took decades before the application of probabilistic grammars to large scale corpora really took off. It is an established, booming field now, both for developmental and adult corpora, and in many languages. Its combination with model-theoretic semantics, however,

<i>Production Rule</i>	<i>Probability</i>	<i>Semantic function</i>
1. NP → N	$a_1$	identity
2. NP → AdjP	$a_2$	identity
3. NP → AdjP + N	$a_3$	intersection
4. NP → Pro	$a_4$	identity
5. NP → NP + NP	$a_5$	choice function
6. AdjP → AdjP + Adj	$b_1$	intersection
7. AdjP → Adj	$b_2$	identity

FIGURE 3 Model-theoretic semantics for Adam I probabilistic noun phrase grammar (From Suppes 1973).

is still a rare commodity. For completeness' sake, the *References* below also lists the original papers of the Suppes team during the 1970s.

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