How Do Children Become Flexible in Their Use of Grammatical Categories? The Aspect Hypothesis Revisited

Jekaterina Mažara and Sabine Stoll

1. Introduction

Verbs are not only the semantic center of information in an utterance denoting and locating events in time and space but also form the morphosyntactic anchor point of information in a sentence. The verbal system of a language thus plays a pivotal role in language acquisition. Learning about the complex features and functions of verbs is one of the main challenges in early first language acquisition. The earliest verb forms in children’s production are grammatically and lexically specific constructions, which are presumably rote learned (Lieven et al., 1997; Pine & Lieven, 1997; Tomasello, 1992, 2000, 2003). During this phase, children hardly display any flexibility of usage; but soon after using the first rote-learned constructions children start to produce new forms and apply them to new contexts. So far, relatively little is known about the details of this generalization process.

Here we focus on the development of flexibility in the use of Russian verb morphology. We analyze the development of combinations of grammatical markers and lexical elements from the earliest phase of verb production to the point where children are approaching the flexibility displayed by surrounding adult speakers. A central category of the Russian verbal system is grammatical aspect, which expresses the viewpoint onto the temporal structure of an action or event. **Perfective aspect** indicates a temporally bounded, external view of a completed event (Comrie, 1976), e.g. *on s’el jabloko* ‘He finished eating an apple’, whereas **imperfective aspect** puts the focus on the internal process of a temporally extended action, e.g. *on el jabloko* ‘He was eating an apple’. In Russian, aspect interacts in complex ways with tense morphology and lexical aspect (also called Aktionsart).

There is enormous cross-linguistic variation in whether and how languages mark aspectual relations. However, results from a number of languages have
shown that there are consistent regularities in how tense-aspect categories evolve in early development. Correlations between verbs denoting a defined endpoint (telic verbs) and grammatical marking of past tense and perfective aspect as well as between verbs without a defined endpoint (atelic) and non-past imperfective marking were found in early acquisition of a number of different languages (cf. e.g., Bloom, Lifter, and Hafitz, 1980; Harner, 1981; Shirai and Anderson, 1995; Clark, 1996; Johnson and Fey, 2006 for English; Bronckart and Sinclair, 1973 for French, Antinucci and Miller, 1976 for Italian; Li and Bowerman, 1998; Shirai 1998; Li & Shirai, 2000 for Japanese; Stoll & Gries, 2009; Gagarina, 2000; Bar-Shalom, 2002 for Russian; Li, 1990; Li & Shirai, 2000 for Mandarin; Aksu-Koç, 1998 for Turkish; Stepnany, 1985 for Greek; Weist et al., 1984; for Polish; as well as self-organizing feature map models, cf. Li, 2000; Li & Shirai, 2000).

These correlations and a possible cause are summarized in the Aspect Hypothesis (Shirai & Anderson, 1995). The Aspect Hypothesis proposes generalizations of children’s early verb form use in terms of preference for specific combinations of tense, grammatical aspect, and inherent semantic properties of the verb. According to Shirai and Anderson (1995), children form prototypes of categories based on semantic properties of verbs. They are able to use the matching morphology with these prototypes first, before they extend it to other verbs. Two predictions of the Aspect Hypothesis are applicable to Russian (Shirai & Anderson 1998: 282f):

1. In languages that encode the perfective/imperfective distinction, imperfective past develops later than perfective past. Imperfective past marking is initially used mostly with states and activities.¹
2. Past marking is at first used predominantly on achievement and accomplishment verbs (verbs denoting actions/events with an inherent end point); only later it is extended to activities and states (actions/events without an inherent end point).

The Aspect Hypothesis predicts that these generalizations hold during the early phase of verb use as well as during early development of flexibility. The child should move through an intermediary phase of higher flexibility within these categories than across them.

Interestingly, these correlations are not restricted to child language but are also found in child-directed speech, but to a lesser degree (Shirai & Anderson, 1995). During development, these correlations in child speech gradually decrease to the level of adults. This is a problem for the proposed prototype account that was already addressed by the authors themselves (as well as Andersen & Shirai 1996; Li et al. 2001; Boland 2006, Bertinetto et al. 2015). If the input distributions

---

¹ The four time schemata Vendler (1967) developed for English verbs are states, activities, accomplishments, and achievements. Examples for each of the four are love, know (states), read, sleep (activities), run a mile, eat a bowl of soup (accomplishments), find, discover (achievements).
line up with the initial production, then there is not enough evidence to posit the
cognitive preference of the prototypes. Bertinetto et al. (2015) propose that there
are no universal cognitive preferences; instead, children build the categories of
their language based on the distributions of overt markings in their target language.

Evidence against prediction 1 was provided in an analysis of longitudinal data
from 4 Russian children. Verbs of both aspects with the past tense start increasing
in flexibility around the same time (Mažara & Stoll, 2019). Even in the earliest
productions, past morphology is found across both aspects. Here, we address
prediction 2 and test whether Russian children’s use of morphology reflects a
preference for the combination of (1) past tense marking and verbs with an
inherent endpoint and of (2) non-past and verbs without an inherent endpoint.

2. The Russian verb

2.1. Verb morphology in Russian

Russian is a language with relatively complex verbal morphology including a
semantically and morphologically complex category of grammatical aspect which
interrelates with tense. Grammatical aspect in Russian is a binary
perfective/imperfective distinction; each verb form is either perfective or
imperfective.2 In contrast to English, which has one single aspectual marker
(-ing), Russian has multiple grammatical markers for the perfective aspect (mainly
prefixes and one suffix), and one suffix (with various allomorphs) for the
imperfective aspect as well as suprasegmental and zero marking. The
morphological marking of aspect is subject to several constraints which might
help the learner make generalizations about the complex morphology. However,
for every constraint there are exceptions (Stoll, 1998). Morphologically,
perfectives are typically derived from imperfectives by prefixation (with a few
exceptions). A simplified overview is presented in Table 1.

<table>
<thead>
<tr>
<th>Table 1: Example of derivation of aspeertual forms</th>
</tr>
</thead>
<tbody>
<tr>
<td>imperfective</td>
</tr>
<tr>
<td>simplex</td>
</tr>
<tr>
<td>čitat’ ‘to read’ + prefix</td>
</tr>
</tbody>
</table>

Prefixes typically carry an additional lexical meaning in addition to providing
aspectual marking. The resulting meaning of the new perfective verb cannot be
derived via simple rules, since there is no one-to-one relationship between
prefixes and the resulting meaning change in the verb they are attached to.

2 There is a number of biaspeertual verbs that use the same form for both aspects. However,
they represent a specific aspect according to context.
Furthermore, many verbs can combine with multiple prefixes, while others are restricted in their combinability (Timberlake, 2004). Therefore, a certain degree of rote learning is required.

On the functional level several temporal and contextual features influence the use of the two aspects. Imperfectives are the unmarked form and can appear in a greater variety of contexts. Put simply, Russian imperfective verbs are used when the duration of an action is highlighted, without placing focus on the beginning or end border of the action (on čital knigu ‘he was reading a book’) or if the action is presented as a complete event sometime in the past (on čital etu knigu ‘he has read this book (at some point)’). Perfective verbs are used when a boundary of a verb is in focus (Bickel, 1997; Breu 1985), be it the beginning, end or result of the action or both (on pročital knigu ‘he (has) finished reading the book’). However, in practice there are finer semantic and pragmatic distinctions between contexts.

Russian has three tenses. Present tense occurs exclusively with imperfective verbs. Past tense occurs on verbs of both aspects. Future tense is marked on perfective verbs through the morphemes that mark present tense on imperfectives. Imperfective verbs use a periphrastic construction (inflected form of ‘to be’ + infinitive of the main verb). In this study we focus on the acquisition of synthetic morphology. Table 2 provides examples of the synthetic tense-aspect morphology Russian children must master to be fully proficient users of language.

<table>
<thead>
<tr>
<th></th>
<th>imperfective verbs</th>
<th>perfective verbs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>present</strong></td>
<td>ja čita-ju</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>‘I am reading’</td>
<td></td>
</tr>
<tr>
<td><strong>future</strong></td>
<td>analytic construction</td>
<td>ja pročitaju etu knigu</td>
</tr>
<tr>
<td></td>
<td>ja budu čitat’</td>
<td>‘I will read/finish reading this book’</td>
</tr>
<tr>
<td></td>
<td>‘I will read’</td>
<td></td>
</tr>
<tr>
<td><strong>past</strong></td>
<td>ja čitala</td>
<td>ja pročitala etu knigu</td>
</tr>
<tr>
<td></td>
<td>‘I read/was reading’</td>
<td>‘I finished reading this book’</td>
</tr>
<tr>
<td><strong>imperative</strong></td>
<td>čitaj!</td>
<td>pročitaj!</td>
</tr>
<tr>
<td></td>
<td>‘read!’</td>
<td>‘read!’</td>
</tr>
</tbody>
</table>

3 We exclude reflexive marking, because it does not occur systematically on all verbs (Timberlake 2004). For the sake of completeness, we also must mention that Russian has a number of participle forms. These were also excluded from this study because they are hardly ever used in spoken Russian, and their use differs from that of other verb forms.
2.2. Semantic verb classes

The lexical temporal categories are known under a number of different terms such as Aktionsart (Agrell, 1908), time schema (Vendler, 1967) or lexical aspect (Timberlake, 1985; Smith, 1983). To avoid confusion, we will use aspect for the grammatical aspect of verbs and Aktionsart for the inherent temporal properties.

Many studies of aspect, both in studies of general linguistic work and especially also in child language acquisition, use the Vendlerian classification (Vendler 1967) of inherent temporal properties of verbs (cf. Shirai & Anderson, 1995). This classification distinguishes four categories: states, activities, accomplishments, and achievements. For Russian, however, this distinction is both insufficient and inappropriate. Therefore, rather than following the same classification for all languages, we adopt a different approach taking language-specific distinctions into account (Stoll, 1998, 2001). The classification is based on a set of primitives: boundaries and phases, which can combine in various ways to create the categories needed for each language (cf. Bickel, 1996, 1997; Breu 1985). We use the classification outlined in Table 3, which proposes five Aktionsarten for Russian (Stoll 1998):

### Table 3: Aktionsarten in Russian

<table>
<thead>
<tr>
<th>Aktionsart</th>
<th>example</th>
<th>aspect</th>
</tr>
</thead>
<tbody>
<tr>
<td>telics</td>
<td>event/action includes an inherent endpoint</td>
<td>umeret’ ‘to die’</td>
</tr>
<tr>
<td>duratives</td>
<td>state/action without an inherent endpoint</td>
<td>igrat’ ‘to play’</td>
</tr>
<tr>
<td>ingressives</td>
<td>beginning of an event/action</td>
<td>zagovorit’ ‘start to talk’</td>
</tr>
<tr>
<td>delimitatives</td>
<td>temporally bounded actions/states</td>
<td>počitat’ ‘to read for a while’</td>
</tr>
<tr>
<td>semelfactives</td>
<td>action that happens punctually and only once</td>
<td>stuknut’ ‘to knock once’</td>
</tr>
</tbody>
</table>

A semantic core meaning might belong to different Aktionsart(en) after derivation. For example, govorit’ ‘to speak’ is durative in its core form and becomes telic as dogovorit’ ‘finish speaking’ or delimitative as pogovorit’ ‘to talk for a while’. A specific prefix used for derivation can lead to different outcomes, depending on the stem it is combined with, e.g. the same surface form of the prefix za- can result in an ingressive or a telic verb. Combined with the verb govorit’ to zagovorit’ ‘to start talking’ the meaning is ingressive, whereas in combination
with *pyrgnut* ‘to jump’, the resulting meaning of *zaprygnut* ‘to jump somewhere/onto something’ is telic. To make matters even more complex, the same Aktionsart can have multiple prefixes associated with it.

### 3. Data

We use data from an audio-visual longitudinal corpus of 5 Russian children (Stoll & Meyer, 2008). All data were collected in monolingual families in St. Petersburg, Russia. The recordings were made in naturalistic settings and include the focal child (or children), siblings and a varying number of surrounding adults. The children were recorded for one hour each week over several years. Since we examine the early stages of verb production here, we focus on the 4 children of the corpus, whose recordings began before the age of three. When making comparisons to adult speech, we exclude all utterances by children other than the focal children. The entire corpus consists of approximately 1.95 million transcribed and morphosyntactically annotated words. Table 4 summarizes the number of utterances, words, and verbs uttered by each focal child and surrounding adults as well as the age range during which the focal children were recorded. All verbs were annotated for Aktionsart manually according to the definitions and tests in Stoll (2001). Interrater reliability is at 93.5% agreement, with Cohen’s kappa at 0.85.

#### Table 4: Overview of focal children’s age range and production

<table>
<thead>
<tr>
<th>Target Child</th>
<th>Age span</th>
<th>Number of recordings</th>
<th>Produced by child</th>
<th>N(tokens)</th>
<th>Produced by adults</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>utterances</td>
<td>words</td>
<td>verbs</td>
</tr>
<tr>
<td>1</td>
<td>1;8.10 - 4;8.21</td>
<td>130</td>
<td>124,497</td>
<td>241,948</td>
<td>38,843</td>
</tr>
<tr>
<td>2</td>
<td>1;4.23 - 4;1.24</td>
<td>109</td>
<td>40,341</td>
<td>57,929</td>
<td>5,411</td>
</tr>
<tr>
<td>3</td>
<td>1;3.24 - 4;9.29</td>
<td>123</td>
<td>45,412</td>
<td>74,926</td>
<td>10,733</td>
</tr>
<tr>
<td>4</td>
<td>1;11.28 - 4;3.12</td>
<td>67</td>
<td>43,962</td>
<td>97,397</td>
<td>16,585</td>
</tr>
</tbody>
</table>

If the predictions made by the Aspect Hypothesis hold for Russian, development should follow these tendencies: (1) past forms are used predominantly on perfective telic verbs, and only later extended to imperfective telics and duratives, and (2) imperfective past develops later than perfective past.

### 4. Methods

#### 4.1. Computing phases of development

First, we want to find out whether there are different stages of verb use in the development of the verbal paradigm in Russian early language acquisition. To be able to compare verb forms produced during the earliest phase of children’s...
production with that of the later phase, we performed a segmented regression on the additive growth of each child’s full verb form inventory. As previously stated, it has been claimed that early production is characterized by a small number of frequently repeated items. During this phase, children add few new forms to their inventories, keeping the growth curve flat. This is followed by a phase later in development, with a rapid increase in verb forms. Here we use segmented regression to calculate the point at which that change occurs by estimating significant changes in the slope of the regression.

With the exception of Child 5, all children exhibit a flat first phase with a steep increase later on. The estimated breaks happen for Child 1 at age 2;2, Child 2 at age 3;5, and Child 3 at age 2;3.

4.2. Analysis 1: Analysing verb form use in the two phases

Assessing the development of flexibility of form use in naturalistic corpora is difficult, because perfect correspondence of context is never given. However, limiting the instances to a predefined set is also inadequate, since it artificially diminishes the range of produced forms. Therefore, we conduct two analyses. The first restricts adult production to compare the distribution of forms produced by the children and the surrounding adults within the same amount of tokens. To do this, we take the entire number of tokens produced by each child during their first phase and extract the lemmas these forms belong to. Then, we sample the same lemmas and an equivalent number of tokens from the adults as well as from each child’s second phase. This allows us to assess the flexibility for a controlled group of lexical items within a controlled sample size.

To compute the distance between the distributions of each child’s first phase and the sample from adult speech, we use Jensen-Shannon divergence (Lin 1991). This measures the distance between two probability distributions over the same elements. The closer the resulting number is to zero, the more alike the two distributions are.

4.3. Analysis 2: Development of flexibility over time

In the first analysis, the matching of lemmas and number of tokens allows us to make a statement about the diversity of forms used in the entire first phase. However, we cannot measure development in the same way. To measure development of flexibility from week to week, we must characterize the production during that week and compare it systematically to the production of

---

5 Child 5 is an early talker and shows a steady increase from the start of the recording period, which is similar in its shape to that of adults, albeit on a smaller scale. Essentially this means that we cannot know whether Child 5 has acquired and used many of the forms before or is acquiring them during the recording period, but doing so at a faster pace than the other children.
adults within the same recording. This allows us to include the entire production of each session for both children and adults.

To assess the flexibility of form use, we compute the entropy (Shannon, 1948) of the production of each child and the corresponding surrounding adults. Entropy measures the rate at which a process generates information; it characterizes the balance of frequency distributions over a set of elements. The more equally the probability of produced elements is distributed, the less predictable, and hence more informative, the output. Early child language is usually characterized by the repeated use of a few forms, while other forms might appear only once. This would result in a skewed distribution, highly predictable output, and low entropy. The formula for Shannon entropy is given in (1):

\[ H(X) = -\sum_{i=1}^{N} p(x_i) \log p(x_i), \]

where \( N \) is the number of distinct forms and \( p(x) \) is the probability of occurrence of a specific form.\(^6\)

We bootstrap the data (i.e. sampling with replacement) for 100 iterations per session to obtain a range of measurements for each data point. The entropy is measured for the focal child as well as for the surrounding adults; then we divide the child’s entropy measure by that of the adults. The resulting entropy ratio indicates the relative development: a number below 1 means the child’s flexibility of verb form use is below that of surrounding adults in the same session, while a ratio fluctuating around 1 represents the child approaching adult level of flexibility.

We divide the data by grammatical aspect and Aktionsart. Then we compute the entropy of distinct lemmas used with the forms of the verb paradigm: i.e. distinct lemmas used with past vs. non-past forms for telics and duratives, respectively.

Finally, we fit a generalized additive model to the bootstrapped entropy ratios and conduct a segmented regression to estimate the points in development at which flexibility increases. Note that this computes a different increase from the one discussed in 4.1.; the mere addition of forms to the inventory does not necessarily mean an increase in the flexibility of use of those forms.

5. Results
5.1. Comparing the distribution of forms in each phase

The early production of children in Phase 1 contains only verbs of telic and durative Aktionsart. Figures 1a and b exemplify the distributions of grammatical markers used with telic and durative verbs of Child 1 in Phase 1. The raw numbers of uses of a particular form (reflected in the distribution of tokens, Figure 1a) show a greater imbalance in the distribution in the child’s production than in that

---

\(^6\) For the computation of entropy over time we used the Chao-Shen estimation of entropy, a measure that accounts for unseen types (Chao & Shen, 2003).
of adults. However, looking at the distribution of verb form types (Figure 1b), the distribution of forms across the Aktionsarten is much closer to that of adults, with very similar distributions.

![Figure 1a: Distribution of grammatical markers across Aktionsarten during phase 1, distribution of tokens](image1)

![Figure 1b: Distribution of grammatical markers across Aktionsarten during phase 1, distribution of types](image2)

The Jensen-Shannon divergence (JSD) also shows a greater distance between the distributions of tokens than types. Both decrease in the second phase. However, the decrease in the distance of the token distributions is smaller. This is not unexpected, since the use of forms depends on context and tends to vary more than the types in the inventory.

The average JSD between children and surrounding adults during phase 1 for the distribution of types is 0.129, and 0.551 for tokens. These numbers decrease to 0.053 and 0.156 for types and tokens, respectively, in phase 2. The comparison of distributions between each child’s own production during the two phases results in numbers very similar to those computed for the difference between the
children’s production and surrounding adults: 0.12 for types and 0.513 for tokens.7

5.2. Development of diversity of form use over time

Figures 2 and 3 show the development of entropy ratios in the focal children in relation to surrounding adults over time. The data of each recording session was bootstrapped 100 times and each point represents one such computation. The regression lines represent the fitted generalized additive model, while the orthogonal lines show the estimated change points of the regression, which indicate the onset of the increase in flexibility. The dotted line shows where this change takes place for past forms, while the dashed line represents the same for non-past forms.8

Figure 2: Entropy ratios for telic perfectives

Figure 2 shows the development of past and non-past morphology use with different lemmas (i.e. lexical items) for perfective telic verbs. An increase in the variety of lemmas indicates an increase of flexibility, since the child is not restricting his/her use to one specific stem+morpheme combination. Figure 2

---

7 Since Child 5’s first phase predates the recordings, their production and distributions were only computed for the comparison of phase 2 production of the child to a matched sample from adults during the same time.

8 Once more, Child 5 does not show this change from item-specificity to more flexible use, since his item-specific stage predates the recordings.
demonstrates that the predicted facilitation for the acquisition of past forms does not hold for Russian, since the two lines are temporally close together. Were the prediction of the Aspect Hypothesis outlined above to hold, we would expect to see a delay in the increase of flexibility.

Similarly, Figure 3 shows that the development of flexibility of use of non-past forms with duratives (which correspond to activities and states in the Vendlerian classification used in the Aspect Hypothesis) is not quicker than that of past forms. This shows that the predictions of the Aspect Hypothesis do not hold here either.

Figure 3: Entropy ratios for durative imperfectives

6. Discussion

Our results show that Russian children do not pass through an intermediary phase of prototype categorization during their development of verb morphology. Instead, they use morphology across grammatical aspect and Aktionsart early on. This suggests that the predicted facilitation of certain combinations of grammatical aspect, Aktionsart, and tense morphology does not hold for any of the combinations. Instead of building up prototypes, children are sensitive to the distributions in input.

A main take-away from this study is that it is essential to consider token and type distributions as two different pieces of information. Most of the prior work on this subject focused on the counts of categories in language use. That, however, only reflects a part of language use, which highly depends on context and each speaker’s expressive needs. A look at the distribution of types, on the other hand,
gives insight into the development of the inventory. Statements about learnability or cognitive preference of forms are hardly justifiable when they are based on the distribution of tokens uttered in a particular time window.

The method we propose in this paper allows us to obtain a systematic comparison to adult production with a high temporal resolution in the same context of speech. Furthermore, entropy evaluates both the amount of types as well as the distribution of tokens across these types.

References


