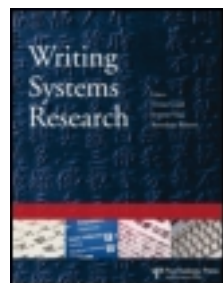


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Young children's knowledge about the spatial layout of writing

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Children who are knowledgeable about the basic properties of writing when formal literacy instruction begins are better prepared to benefit from that instruction than children who know less about this topic. In the present study, we examined US preschoolers' knowledge about one aspect of writing: its spatial arrangement. Our participants, who had a mean age of 4 years, 2 months and who could not read any words in a list of simple words, were significantly above the level of chance at determining that horizontally arranged strings of letters are more like the writing in books than are letters with vertical, diagonal or scattered arrangements. Contrary to the theory that children learn about the characteristics of writing that hold true in all writing systems before they learn about the characteristics that are specific to their own writing system, young children did not show a priority for vertical arrangements. The results are more consistent with the hypothesis that preschoolers apply their statistical learning skills to the spatial layout of writing.

Keywords: Print awareness; Print concepts; Emergent literacy; Statistical learning; Writing orientation.

According to the emergent literacy perspective, children in literate societies learn about certain basic properties of writing before formal literacy instruction begins (e.g., Whitehurst & Lonigan, 1998). This knowledge helps them to benefit from the instruction that is provided in school. Indeed, children who start formal literacy instruction with higher levels of print-concept knowledge, also called print awareness, tend to become better readers than those who begin with less knowledge about print (e.g., Storch & Whitehurst, 2002). Knowledge about print has thus come to play a major role, together with phonological awareness, in conceptualisations of emergent literacy (Whitehurst & Lonigan, 1998).

Most tests of print-concept knowledge for English-speaking children (e.g., Clay, 1979; Justice, Bowles, & Skibbe, 2006) tap children's knowledge of a variety of properties of writing. These include the distinction between the front and the back of a book, between

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upper-case letters and lower-case letters, and between written words and pictures. Other items assess children's knowledge that writing is read from left to right and from the top to the bottom of a page. In the present study, we looked in detail at US preschoolers' knowledge of one specific characteristic of writing: its arrangement on the pages of books. We focused on this aspect of print knowledge for two reasons. First, knowledge about the proper arrangement of the symbols of writing is important for both reading and writing. Second, writing arrangement serves as a good test case for examining what preschoolers know about the visual properties of writing and how this knowledge develops.

As a background for our study, we first consider the spatial layout of different writing systems and the layout of writing in books for US preschool children. We then present our research questions and hypotheses, discussing how the study of writing's arrangement can shed light on general questions about how children's knowledge about writing develops.

Spatial layout of different writing systems

The basic units of all writing systems, whether they represent phonemes, syllables or morphemes, are arranged in an ordered sequence rather than being randomly scattered over a page. This property of written language may be seen as an attempt to map the temporal linearity of spoken language (Brenneman, Massey, Machado, & Gelman, 1996). Text is normally arranged vertically or horizontally, parallel and perpendicular to the edges of the writing surface. This is a universal characteristic of writing, that is, one that holds true in all systems. The specific orientation of the lines of writing is, in contrast, a script-specific convention. In some writing systems, such as English and Hebrew, lines of print are normally horizontal. In other systems, such as Mongolian and Japanese, lines of print are typically vertical. Vertical writing was formerly the norm in China and Korea too, losing out to horizontal writing only during the course of the twentieth century. The orientation of the lines of print is thus a convention that children in each society must learn.

Spatial layout of writing in books for US children

English writing in books for adults is normally horizontal, but is this true in books that are designed for preschool children? Some books for preschoolers include print that deviates in some ways from the adult norms, as when a word curves around the edge of a pictured object rather than being arranged along a horizontal line or when print is coloured rather than black (Dynea, Justice, Pentimonti, & Piasta, 2013; Zucker, Justice, & Piasta, 2009). Previous studies have not examined the frequency of specific types of deviations, however. In a preliminary study, therefore, we examined the orientation of the writing in books that are popular among US preschoolers. Our goal was to determine whether horizontal writing is the norm and to obtain information about the frequencies of it and other arrangements.

We selected books for the preliminary study on the basis of recommendations from children, librarians, and teachers. We asked the parents of nine typically developing children ranging in age from 3;5 (years; months) to 5;4 to pick their child's three favourite books. We also asked three children's librarians and 10 preschool teachers to recommend five books that were popular among 3- to 5-year-olds. These procedures yielded a total of 73 books (some books were recommended by different sources, in some cases as many as four separate times), almost all of them storybooks.

For the cover of each selected book and for each interior page of the text that included print, we examined whether the writing was all horizontal or whether it had some other arrangement. In the few cases in which a book had more than 25 interior pages, we randomly chose 25 pages for analysis. On 80% of the pages, all of the print was arranged horizontally. There were no pages on which all of the print was vertical and no pages in

which letters were randomly scattered over the page. The print was all diagonal on only 2% of the pages. On most of the pages that did not have all horizontal print, the majority of the words were aligned horizontally and a few had another arrangement. These other arrangements sometimes occurred when print was embedded within a picture or a speech bubble. For example, a storybook that included a picture of books on a shelf showed the writing in a pictured book running diagonally rather than horizontally, consistent with the book's orientation in the picture. In a second analysis, we randomly selected one word from each page of each book and noted its direction. We found that 92% of the words had a horizontal arrangement. Those that were not horizontal had a variety of other arrangements.

The results of our preliminary study indicate that the large majority of the writing that US preschoolers see in books is arranged horizontally. Vertical writing is infrequent, and not more common than other unconventional arrangements.

Research questions and hypotheses

Young US children are exposed primarily to horizontal writing in books, but do they take in information about this arrangement? Our first research question concerned when US children learn that writing is horizontally arranged. Specifically, do children show some knowledge of this arrangement even before they can read simple words? The emergent literacy perspective suggests that children acquire a good deal of knowledge about print during the preschool years (e.g., Whitehurst & Lonigan, 1998), but few studies have focused on children's knowledge about the spatial arrangement of writing. Ganapole (1987) and Lavine (1977) reported that US preschoolers tended to reject as writing strings of letters that were not arranged horizontally. However, only three items that had other than horizontal arrangements were included in each of these studies. Ganapole credited children as possessing an understanding of horizontality if they responded correctly to two of the three items, a level of performance that some children may have achieved on the basis of random guessing. Other researchers reported that US children as young as three years of age prefer the letters of their own first name to be arranged horizontally (Hildreth, 1936; Treiman, Cohen, Mulqueeny, Kessler, & Schechtman, 2007). The name plays a leading role in early literacy development, however, and children may not generalise what they know about their name to other words (Drouin & Harmon, 2009; Ferreiro & Teberosky, 1982). We designed the present study to tap children's knowledge about writing's spatial layout in a way that did not involve their own names. We hypothesised that, even before children can read simple words, they develop a preference for horizontal writing.

A second issue that we investigated was how children learn about the spatial layout of writing. One potential answer to this question comes from the influential hypothesis that children learn about the features of writing that are common to all systems before they learn about the features that are specific to the writing system of their society (Chan & Louie, 1992; Lavine, 1977; Puranik & Lonigan, 2011; Tolchinsky, 2003; Tolchinsky-Landsmann & Levin, 1985). To use the terms introduced by Gibson and Levin (1975), children acquire the superordinate features of writing before the ordinate features. According to this hypothesis, which we call the universal-to-specific hypothesis, some features of writing are relatively easy for children to grasp because they "*reflect the basic representational nature of writing that all languages commonly share*" (Puranik & Lonigan, 2011, p. 568). The fact that the symbols of writing are arranged along lines should fall into this category. Whether the lines are horizontal or vertical is an arbitrary convention that is specific to a particular society, and language-specific conventions of this

kind should be more difficult to learn according to the universal-to-specific hypothesis (Brenneman et al., 1996; Puranik & Lonigan, 2011).

The universal-to-specific hypothesis predicts that children should go through a period during which they produce writing that is arranged along a straight line before they know whether the horizontal or vertical arrangement is conventional for their culture. Researchers who have reported that children's productions are often arranged along lines, as opposed to randomly scattered over the page, have not usually provided information about whether the lines are horizontal or vertical, however (Levin & Bus, 2003; Puranik & Lonigan, 2011). It is thus difficult to evaluate whether children in such countries as the US and Israel go through a period during which they write vertically as often as horizontally, as the universal-to-specific hypothesis predicts. A study in which US preschoolers were shown the letters of their name arranged in various ways did not find support for the universal-to-specific hypothesis in that children did not accept the vertical arrangement, which is conventional in some writing systems, more often than the diagonal arrangement, which is not typical of any writing system (Treiman et al., 2007). As mentioned earlier, however, findings with children's names may not extend to words in general.

A different view of how children learn about the spatial arrangement of writing comes from conceptions of learning that emphasise implicit statistical learning. According to the statistical learning hypothesis, children learn which features are more and are less common in the examples of writing that they see. That is, they learn about the statistics of their environment. Previous research shows that statistical learning is available from an early age. Infants, who find speech to be interesting and attractive (Shultz & Vouloumanos, 2010), use their statistical learning skills to begin learning about its phonological properties even before they learn the meanings of the phonological forms. For example, infants who are exposed to English appear to learn, somewhere between six and 10 months of age, that two-syllable words are more likely to have stress on the first syllable than the second syllable (Jusczyk, Cutler, & Redanz, 1993). Writing is less attractive to infants and children than speech, and writing is also less ubiquitous. However, some research suggests that children in literate societies use their statistical learning skills to pick up certain characteristics of writing before formal literacy instruction begins. For example, a number of 4- to 5-year-olds appear to have learnt that certain letters and groups of letters occur more often in printed words than other letters and groups of letters (Pollo, Kessler, & Treiman, 2009). In the present study, we tested the idea that children's knowledge about the spatial layout of writing develops in the way predicted by the statistical learning hypothesis. If so, we would not expect US children to show a period of development during which they produce and accept both horizontal and vertical writing because, as the results of our preliminary study show, vertical writing is quite uncommon.

To gain information about how and when children learn about the spatial layout of writing, we prepared displays in which letters of the Latin alphabet were presented in horizontal, vertical, diagonal and scattered arrangements. The letters did not form real words. Pairs of displays differing in orientation were shown on facing pages of a booklet. Children were asked to point to the display in each pair that looked more like the way writing in a book should look. If preschoolers possess some knowledge about the orientation of writing, then they should respond in a non-random fashion to at least some types of pairs. If children's knowledge about the orientation of writing develops in the way predicted by the universal-to-specific hypothesis, then children should be less likely to choose horizontal displays, which are typical of their writing system, when they are paired with vertical ones, which are typical of certain other writing systems, than when they are paired with diagonal or scattered displays, which are unusual in the sense that they are not normally found in any writing system. In addition, children should prefer vertical displays

over diagonal and scattered ones. If children's knowledge about the orientation of writing develops in the way predicted by the statistical learning hypothesis, then children should choose horizontal displays over vertical ones at the same rate that they chose horizontal displays over diagonal and scattered ones. In addition, children should not show a preference for vertical displays when offered a choice between these displays and diagonal or scattered ones.

METHOD

Participants

The participants were 55 preschoolers (33 boys) with a mean age of 4;2 (years; months) and a range of 3;2 to 5;11. Most were White and of middle-class backgrounds. The children attended preschools and day-care centres in the area of St. Louis, Missouri. At these preschools and day-care centres the children were frequently read to and exposed to books, but they did not receive formal literacy instruction. As described below, none of the participants could read any of the words in a list of simple words.

Stimuli

Each child was presented with 30 pairs of displays that assessed knowledge about the orientation of print and also eight filler pairs. The displays in each pair were printed on 8×13 cm pages and were placed on facing pages of a booklet. There were six pairs that compared each of horizontal versus vertical, horizontal versus diagonal, horizontal versus scattered, vertical versus diagonal, and vertical versus scattered. The horizontal, vertical and diagonal displays were arranged as three lines, each containing 12 letters of the Latin alphabet. The letters on each line of these displays were arranged in groups of between three and five letters. The letters within each group were spaced similarly to the letters in a word but did not form English words. For half of the diagonal displays, the lines ran from the bottom left to the top right of the page. For the other half, the lines ran from the top left to the bottom right. The 36 letters in each of the scattered displays were arranged haphazardly, not on lines, and they covered approximately the same area as the letters in the other displays. A different set of letters was randomly chosen for each display, and identical letters were never adjacent to one another. The letters were upper-case, 7 mm high, and black on a white background.

For the filler pairs, each page had an image of a different common object, and children were asked to make simple category judgements about the pictured objects. For example, one filler item contrasted pictures of a wagon and a chimpanzee and the child was asked to pick the animal. The filler pairs were designed to be easy, and indeed the children almost always produced the correct answers on these pairs.

Three booklets were prepared that differed in the ordering of the pairs. Within each booklet, the orientation pairs were in a randomly chosen order and filler pairs were placed after every three or four orientation pairs. Approximately one third of the children were assigned to each booklet.

To assess children's ability to read simple words, 11 cards were used. Two unrelated words were printed in upper case on each card. These were simple words such as *no* and *stop*, the same words used by Treiman et al. (2007). Each card also contained one easily identifiable picture. The cards measured 14×22 cm. Twenty-five children in the same age range as the nonreaders of the final sample could read one or more of the words and were not included in the analyses.

Procedure

The children were tested individually in a quiet location at their school. To begin, the child was introduced to a puppet. The experimenter told the child that the puppet came from a different planet and needed to be told how people do things in our world. Several practice trials were given to show the child that the puppet needed to be taught about writing and books. On one practice trial, for example, the child was shown a book and a toy and was asked to show the puppet the book. Incorrect responses on the practice trials, which were infrequent, were corrected. For the orientation pairs, the child was asked to look at the two displays and show the puppet which display looked most like writing as seen in books. For the filler pairs, the child was asked to look at the two pictures and tell the puppet which one belonged to the specified category.

For the reading task, children were shown the cards in a randomly chosen order. They were invited to say anything they recognised on the card. If a child did not identify all three items on a card, the experimenter pointed to each word and picture in turn and asked the child to try to identify it.

RESULTS

Preliminary analyses showed that children responded similarly to pairs containing diagonal displays and those containing scattered displays ($p > .42$ according to t tests). Given the similar results with these arrangements, and given that they are unusual in any writing system, we pooled the results for pairs including these arrangements in the analyses that follow. The main analyses, therefore, involved three types of pairs. One type of pair, which we call *native* versus *unusual*, contrasted a horizontal display, which is typical in writing seen by US children, with a display that is atypical in any writing system, either diagonal or scattered. A second type of pair, labelled *native* versus *foreign*, contrasted a display that is typical in the children's writing system (horizontal) with a display that is typical in some other writing systems of the world (vertical). The third type of pair, *foreign* versus *unusual*, contrasted a display that is conventional in some foreign writing systems (vertical) with a display that is not typical of any writing system (diagonal or scattered). Table 1 shows the mean proportion of responses in which children picked the first-listed alternative in each of these types of pairs: the horizontal display for the native versus unusual pairs and native versus foreign pairs, and the vertical display for the foreign versus unusual pairs.

We performed statistical analyses at the trial level using mixed model analyses. We used the software package lme4 (Bates, Maechler, & Bolker, 2011), selecting a generalised mixed-effects model with a logit link function because the dependent variable was binary. The models included separate intercepts for each participant and each item and separate slopes for each participant based on item type. Our first model included the fixed factor of pair type: native versus unusual, native versus foreign and foreign versus unusual. We found no significant difference between native versus unusual and native versus foreign

TABLE 1

Mean and standard deviation of proportion choices of first item in each pair type and significance level for difference from chance (.50) by Binomial Test

<i>Pair type</i>	<i>Mean</i>	<i>SD</i>	<i>Difference from chance</i>
Native vs. unusual	0.600	0.255	$p < .001$
Native vs. foreign	0.573	0.286	$p = .004$
Foreign vs. unusual	0.515	0.234	n.s.

pairs ($p = .381$). That is, children were equally likely to choose the horizontal display whether it was paired with a display that is unusual in any writing system (diagonal or scattered) or with the vertical display, which is typical of some systems outside the US. According to binomial tests, children picked the arrangement that is conventional in their own writing system, horizontal, significantly more often than 50% of the time for both the native versus unusual ($M = 60.0\%$) and native versus foreign ($M = 57.3\%$) pairs. Choices of the horizontal display in the native versus foreign and native versus unusual pairs were significantly more common than choices of the vertical display in the foreign versus unusual pairs ($p = .004$). As Table 1 shows, the children did not show a significant preference for the vertical display in the foreign versus unusual pairs ($M = 51.5\%$).

The results are not consistent with the universal-to-specific hypothesis, which predicts that children would have more difficulty choosing horizontal displays when paired with vertical ones than when paired with random or scattered ones, and which also predicts that children would prefer vertical displays over random and scattered ones. However, it is possible that only the younger children in the study showed the patterns that are predicted by the universal-to-specific hypothesis. We therefore fit a second model that included the fixed factors of pair type and child age and the interaction of age and pair type. We treated age as a continuous variable, centring it prior to analysis. This second model fit the data better than the first model according to a log-likelihood test ($p < .001$). This second model showed a significant effect of age ($p < .001$), such that older children were more likely than younger ones to choose the first-listed alternative in the native versus unusual, native versus foreign and foreign versus unusual pairs. The contrast between the native versus foreign and native versus unusual pairs was not statistically significant ($p = .410$), as also found in the first model, and it did not interact significantly with age ($p = .276$). This latter result shows that the younger children in the study, like the older children, were not significantly less likely to select the native horizontal display when it was paired with a vertical display, which occurs in some foreign writing systems, than when it occurs with a display that is unusual in any writing system. The contrast between the pairs that included a display that is typical of the children's own writing system (native versus foreign and native versus unusual) and the foreign versus unusual pairs did interact with age ($p = .026$ according to a model that included by-subject and by-item random intercepts; the model failed to converge when by-subjects random intercepts were included). Older children were more likely than younger ones to choose the native (horizontal) items in the native versus foreign and native versus unusual pairs, and older children were also more likely to choose the foreign (vertical) items in the foreign versus unusual pairs. The interaction arose because the effect of age was larger for the former types of pairs than for the latter type of pair.

DISCUSSION AND CONCLUSIONS

Previous studies of young children's knowledge about print have typically included items tapping children's knowledge of a variety of print characteristics (e.g., Clay, 1979; Justice et al., 2006; Levy, Gong, Hessels, Evans, & Jared, 2006). In the present study, we focused on preschoolers' knowledge about one specific aspect of the English writing system: the fact that text is arranged on horizontal lines. This is an important aspect of writing that children must learn and a good test case for examining different theories about how children's knowledge of writing develops.

Our first research question concerned when US children learn about the spatial layout of writing. In particular, do preschool children who cannot read simple words and who have not received formal instruction in reading or writing show any knowledge that writing in

books is normally horizontal? We found an affirmative answer to this question. The children in our study, who had an average age of a little over four years, showed some knowledge that writing in books is generally horizontal. As a group, the children chose horizontal displays over the other types of displays significantly more often than expected by chance. Although the children's performance was far from perfect, they showed some knowledge of an arbitrary convention of their society concerning the orientation of writing. Although previous studies suggest that preschoolers know that the letters in their own name should be arranged horizontally (Hildreth, 1936; Treiman et al., 2007), the only previous studies to have addressed this issue with regard to writing in general included few items with non-horizontal arrangements (Ganapole, 1987; Lavine, 1977). Our results provide stronger evidence that preschoolers are sensitive to the horizontal arrangement of letters in books, not only to the horizontal arrangement of the letters in their own first names.

Our second question was about how children develop their knowledge about the orientation of writing. The findings suggest that this knowledge does not develop in the way predicted by the universal-to-specific hypothesis. Our participants were not significantly less likely to choose a horizontal display when the alternative was vertical—an arrangement that occurs in some foreign writing systems—than when the alternative was diagonal or scattered—arrangements that are not typical of any writing system. Also, the children as a group did not show the significant preference for vertical over diagonal and scattered arrangements that the universal-to-specific hypothesis predicts. Nor were the results for just the younger children in our study as predicted by the universal-to-specific hypothesis. If the younger children had favoured the vertical arrangement over the diagonal and scattered arrangements, with only the older children knowing that horizontality is typical of English, then younger children should have been more likely than older children to pick vertical displays over diagonal and scattered displays. However, we saw the opposite trend.

The universal-to-specific hypothesis has been influential in the study of children's literacy development (Chan & Louie, 1992; Lavine, 1977; Puranik & Lonigan, 2011; Tolchinsky, 2003; Tolchinsky-Landsmann & Levin, 1985), and it has influenced the study of adult literacy learners as well (Kurvers & Ketelaars, 2011). This hypothesis is founded on the idea that children's ideas about what writing looks like follow from an understanding of its representational nature (Brenneman et al., 1996; Puranik & Lonigan, 2011). Knowing that writing represents language, which extends through time, children expect that the units of writing should be arranged sequentially. Facts about writing that reflect its basic representational nature should be relatively easy to learn according to the universal-to-specific hypothesis, and such facts should be mastered at an earlier age than arbitrary conventions, such as whether the lines of writing are horizontal or vertical (Puranik & Lonigan, 2011). Our results do not support the predictions of the universal-to-specific hypothesis in the case of writing's orientation. They lead us to question the general idea that children construct ideas about how writing should look—ideas about its spatial arrangement and other characteristics—from an understanding of writing's symbolic function.

Rather than building ideas about writing's appearance based on an understanding that it represents language, children appear to pick up on the salient visual properties of the writing that they see. That is, they learn about the statistics of their writing environment. As we found in our preliminary study, most of the writing that US preschoolers see in books is horizontal. Although preschoolers spend more time looking at the pictures than the print in books (Evans, Williamson, & Pursoo, 2008; Justice, Skibbe, Canning, & Lankford, 2005), they appear to acquire some knowledge about the layout of writing from

this and other sources. Consistent with the statistical learning hypothesis, children showed an increasing preference for horizontal displays across the age range represented in our study. Also consistent with the statistical learning hypothesis, young children did not show particular difficulty in rejecting vertical displays or any special preference for them.

The statistical learning hypothesis provides a better explanation of our results on how young children learn about the orientation of writing than does the universal-to-specific hypothesis. The statistical learning hypothesis can also explain preschoolers' knowledge about other aspects of writing's form, such as the fact that some letters and groups of letters occur more frequently than others (Pollo et al., 2009). As children get older, they apply their statistical learning skills to more subtle aspects of writing's form and to the links between symbols of writing and linguistic units (Apfelbaum, Hazeltine, & McMurray, 2013; Deacon, Conrad, & Pacton, 2008; Treiman & Kessler, 2006). Thus, the statistical learning hypothesis can help to explain the development of multiple aspects of writing.

Whereas some studies have examined children's knowledge about various aspects of writing by analysing their written productions (e.g., Brenneman et al., 1996; Chan & Louie, 1992; Puranik & Lonigan, 2011), the present study, like several others (Ganapole, 1987; Lavine, 1977; Levy et al., 2006), asked children to make judgements about examples of writing that were shown to them. Our participants performed significantly above the level of chance, although far from perfectly, at picking horizontal displays over those with other arrangements. In future research, it will be important to compare performance on production and judgement tasks. Previous studies suggest that children's performance on judgement tasks like that used here is related to their home background and other literacy-related skills (Levy et al., 2006), and this is another topic that merits additional study. Although much work remains to be done, the present findings suggest that children apply their statistical learning skills to writing from an early age. Even before US preschoolers can read words themselves, they show some knowledge that words are arranged horizontally on the page.

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