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Learning Novel Word and Novel Concepts in Media and E-media: the Power of Comparisons and the Example of Paired graphics

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Abstract

Adults and children viewed about thirty varied paired graphics derived from school science textbooks and explained meaningful aspects of each item. Verbal responses and eye tracking results indicated that while adult's participants understood most of the items and directed their attention to high relevance aspects of the graphics; children had lower score and did not always direct their attention only to relevant features. In adults, although some variables, such as the typicality of the graphic pairs appeared to influence comprehension, others such as content complexity seemed to have no effect. In children three main categories of errors were found, which were mostly related to the design of the paired graphics. In children, we showed that adding more items did not result in better results in the case of younger students, which we interpreted in terms of less developed executive functions.

Introduction

With the increasing reliance on graphic forms of representation in educational materials, graphicacy has emerged (as literacy-numeracy had) as another fundamental capacity that learners need to develop [1]. Graphicacy can be defined as a set of capacities concerned with interpreting and generating information in graphic form [2].

The studies reported in this paper are exploratory investigations of the paired graphics format widely used in educational illustrations. Paired graphics appear to require that learners engage in distinctive approaches to processing. This paired format was used for a variety of instructional purposes, from showing the relationship between realistic and abstract depictions to portraying the 'before and after' states of target subject matter. Paired graphics typically use a standard layout formula of two pictures positioned horizontally adjacent on the display. This structural convention provides a signal that the component pictures are related and so should be processed together rather than independently. In order to deal effectively with paired graphics, it is likely that the learner would need to perform not only *within* picture processes but also *between* picture processes. Such successive processing cycles approaches could be acquired implicitly over time, because in contrast to text, graphicacy is not currently the subject of explicit tuition and so is typically acquired incidentally. The 2 studies used eye tracking to explore how adults (experiment 1) and primary school children (experiment 2) processed a varied assortment of paired graphics.

Method

Experiment 1.

18 French university students participated. The 37 paired graphics items employed depicted a variety of topics and were based on actual examples (rather than specially designed research materials) from science school books [3] for 10-12 year old children from five countries, Fig. 1. The materials were re-designed for presentation without accompanying text (except for necessary labels). Participants were tested individually and instructed to imagine they were in a classroom situation using books with graphics. They were asked to study each of the items as they typically would in this situation and state what was most important to understanding the item's meaning. Eye movements and verbal responses were recorded. Two independent raters awarded responses for each item either 1 or 0 points for correct and incorrect answers respectively. Three categories of Areas of Interest were used per item. (i) R.AOI1 for location of relevant information in the left hand graphic, (ii) R.AOI2 for location of relevant information in the right hand graphic, (iii) IR.AOI for all locations containing irrelevant information. The size of IR.AOI was (always) greater than the size of the two R. AOIs.

Experiment 2.

21 French children in their last year of primary school (*M* age = 11) participated in one individual session, in June. On the 37 paired graphics used for adults, 6 were excluded. Experimental design and procedure were exactly the same as in experiment 1.

Results Experiment 1, adults

More than 75% of the paired graphics were understood by all participants (*M* = 27.9). Eye tracking results, Figure 2, give a comparison of the total fixation durations ratios on relevant and irrelevant AOIs. Analysis of these data revealed a significant effect of AOI type, F (2, 34) = 17.70, $\eta_p^2 = .51$, $p <$ .0001; relevant AOIs receiving more attention than the irrelevant AOIs, F (1, 17) = 96, $\eta_p^2 = .80$, $p <$ .0001.

A high number of transitions between the two relevant AOIs was recorded. A finer-grained analysis with respect to individual items was performed by two independent judges. This analysis sought to identify possible features of the paired graphics that could influence how readily they were understood. The variables identified included: (i) *typicality of the item*; (ii) *number of entities needing to be compared*; (iii) *conspicuity of the relation (natural or cued)*; (iv) *presence of relevant context*; (v) *prior knowledge.*

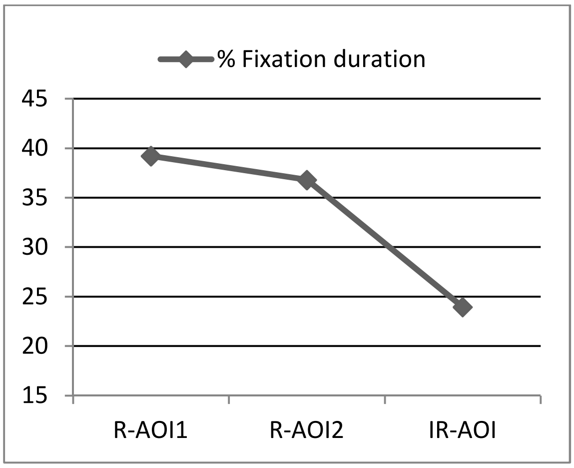

Fig. 2. Examples of paired graphics of the experiments

Fig. 2. Mean percent of fixation duration in AOIs, Adults

Results experiment 2, children

59, 6 % of the paired graphics were understood by all participants (*M* = 18, 47). The analysis of eye tracking results (Fig. 3) revealed an effect of AOI type, F (2, 30) = 5.64, $p < .01$, $\eta_p^2 = .16$; with relevant AOIs receiving only marginally a higher proportion of attention than the irrelevant AOIs; F (1, 30) = 4.14, $p = .051$, $\eta_p^2 = .12$.

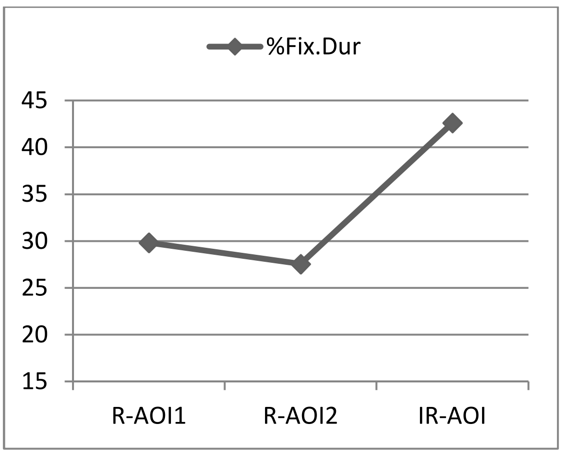

Fig. 3. Mean percent of fixation duration in AOIs, Children

A high number of transitions between the two relevant AOIs was recorded. A finer-grained analysis of errors resulting in misunderstandings of the relation between the two graphics was performed. Depending of the item, 0% to more than 81% of the children made errors. The type of errors indentified included three categories. In the first category, errors were due to *the misunderstandings, or ignorance of conventions and symbols* (an arrow, or of cross-section symbol - line crossing through an object). In the second category, *no relation was found between the two objects* depicted in the pictures, which were considered as two different objects. In the third category, *children found a relation between the two pictures, however, it was a wrong relation based on irrelevant features.*

Discussion

Adult participants understood most (>75%) of the presented paired graphics, with expected attention direction. Primary school children, showed less than sixty percent score and their attention was not always directed toward (only) relevant information. It seems that the explanation was mostly related to the design of the paired graphics. Results will be used as the basis for designing more targeted and structured experiments to investigate the nature of graphicacy and how it develops in children younger than those of the present study. Furthermore, comparison activities could also result in high cognitive costs.

Cognitive costs during comparisons in children

As mentioned above, children do not necessarily understand what should be compared in a comparison setting, in which participants have to find conceptual correspondences between two pictures. In the following paragraphs, we will consider the possibility that young children might also fail in comparison situations because of the cognitive costs of the comparison situation [4] [5].

Our central hypothesis is that these comparisons generate cognitive costs that will be handled more or less efficiently by executive functions, such as working memory, inhibition, and cognitive flexibility. In comparison situations, increasing the number of standards belonging to the same category increases the number of comparisons that must be performed and held in working memory. Salient common perceptual attributes (such as shape) must be inhibited in order to find less salient unifying dimensions (such as texture). Shifting to a new dimension when a salient one, such as shape, is irrelevant for categorization requires cognitive flexibility. We hypothesized that comparison costs might differentially influence different age groups, which motivated the inclusion of two age groups.

We used unfamiliar categories defined by the non-salient dimension "texture". Stimuli were constructed around two dimensions, texture and shape. In order to vary the processing load, we manipulated the number of standards (1, 2 and 4) and the presence of an item belonging to another category (No or 1 contrast item) which had the same shape as one standard stimulus. Adding more items increases texture relevance and decreases shape relevance, but increases cognitive costs. We also compared contrast and no-contrast conditions. The repetition of a non diagnostic dimension value (see Fig. 4) also potentially increases its saliency, even though the comparison should lead subjects to discard it. Therefore children have to inhibit it, a process which might be harder in the younger age group. We predicted that younger children might not benefit from contrast conditions as older children would. In terms of executive functions, age is a crucial factor because the question of how four- and six-year-olds will differentially integrate more comparisons remains open.

Participants

A total of 216 preschoolers were tested individually at school. Two age groups were recruited. The younger children (n= 108, mean age = 48.8m) and the older children (n= 108, mean age = 66.3m) were randomly assigned to one of the six experimental conditions with 18 children per condition. Informed consent was obtained from school and parents.

Materials

Seven sets of artificial grey-scale objects pictured on cards were created. Cards were 12*9 cm (width*height) and objects pictured on the cards were approximately 6*6 cm. Each participant completed two practice trials and five experimental trials. Textures and shapes used in one trial differed from one trial to the next. There were two standards in the 2-0 and the 2-1 conditions and four in the 4-0 and the 4-1 conditions. The standards shared the same texture but had different shapes.

Procedure

The experiment started with two practice trials which were followed by five test trials presented in a random order. Each standard was given a count noun (e.g. "this is a *buxi*" and "this is a *buxi* TOO" for the other standards). In the contrast conditions, a contrast object was introduced below the standard(s) as a non-member of the category (e.g. "this is NOT a *buxi*"). Two test objects (i.e., the shape and the texture match) were introduced and the child was asked to point to the one which was also a member of the category (e.g., "Show me which one of these two is also a *buxi*").

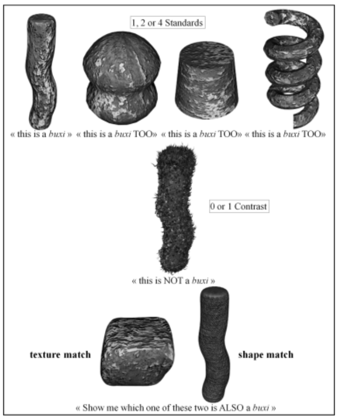

Fig. 4 Sample stimulus set and instructions used in the six experimental conditions that crossed the two factors: number of standards (one, two, or four standards) and contrast (zero orone contrast)

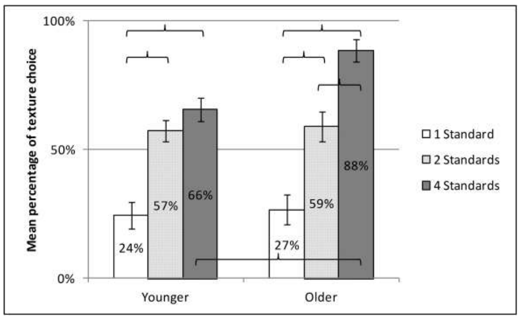

Fig. 5 Mean percentage of texture-based responses (+SEM) as a functionof age and number of standards. Braces show significant differences between columns (p < .05)

Results

Analyses were performed on the mean percentage of texture choices, and on consistency patterns (see below). A 3(Number of standards)* 2(Contrast)* 2(Age) ANOVA was conducted on the percentage of texture choices. The most important result was a marginally significant Age by Number of standards interaction (F (2,217) = 2.94, p = .055, η^2_P = .02). As shown by the Fig.5, there was a difference between the 4 stimuli case for the six-year-olds, at 4-year-olds. This result shows that providing more relevant information for generalization according to a dimension was less beneficial for younger children than for older children. We interpret this difference in terms of differences in executive functions between the two age groups. Younger children have more difficulties to integrate all the relevant information that is provided.

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