CONGRUENCE EFFECTS IN LETTERS VERSUS SHAPES: THE RULE OF LITERACY

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Abstract

In a series of experiments in which participants had to classify stimuli as letters versus shapes we found a differentiation between holistic non-letter processing and analytic letter processing in adults. In a recent study we investigated whether this distinction is also present in literates. We found that the differentiation is absent in illiterates; they uniformly showed analytic perception for both letters and non-letters.

In a recent study (Lachmann, Khera, Srinivasan and van Leeuwen, 2011) we compared a group of adult skilled readers to a group who never learned to read, using the classification task in which a differentiation in processing between letters and non-letters was originally found (van Leeuwen & Lachmann, 2004). In this task, target letters and non-letters (shapes) were surrounded by a task-irrelevant shape. Shapes were classified faster if the target and its surrounding (non-target) were form-congruent as compared to when they differed in shape (when both were form-incongruent). This is an example of the well-known congruence effect (Bavelier, Deruelle & Proksch, 2000); and can be related to early and mid-level visual perception (Boenke, Ohl, Nikolaev, Lachmann & van Leeuwen, 2008). The congruence effect indicates (in an operationally specific sense) holistic perceptual grouping: The surrounding visual information is bound to the target, and is processed faster if both call for the same response. For letter targets, however, the opposite result was found: letters were categorized faster when surrounded by an incongruent non-target (when surrounding non-target was of different visual form than the target) than when the non-target was congruent: a negative congruence effect (Lachmann and van Leeuwen, 2008, 2008 b; van Leeuwen & Lachmann, 2004).

The dissociation in processing strategy was considered a product of a specific analytic strategy optimized during learning to read in order to guarantee a rapid grapheme-phoneme mapping. Binding irrelevant visual information from the surrounding would disturb this fast mapping. The visual structure of the surrounding shape is therefore suppressed (as symmetry suppression for letters, cf. Pegado et al., 2011, Lachmann et al., 2009). Doing so is more difficult for congruent than for incongruent items, resulting in negative congruence effects (Bavelier et al., 2000; Briand, 1994; van Leeuwen & Bakker, 1995).

Thus, we may conclude that in the early or intermediate stages of visual perception, skilled readers process letters using a unique analytic encoding strategy whereas for processing shapes a holistic processing strategy is applied. For illiterates who are unfamiliar with the alphabet, we did not expect such a dissociation. Since illiterates are not able to differentiate letters from non-letter shapes, they were expected to process both letters and non-letter shapes with one and the same strategy. The question in Lachmann et al. (2011) was: what strategy is it, a holistic or an analytic strategy? If holistic, we may conclude that the analytic strategy is a secondary adaptation; if analytic, we may conclude that both analytic and holistic processing are intrinsic, primary strategies of the visual system.

Experiment

There were 32 Indian illiterates who participated in the study (Lachmann et al, 2011). All of them reported that they, while having normal vision and hearing are not able to read neither English nor Hindi, do not speak English, and are not familiar with Latin alphabets. Prior to the experiment their familiarity with the alphabet was determined by using a letter identification test. All participants from illiterate group included in the study performed within chance level. The control group consisted of 26 Indian adults who were able to read fluently and to write in English.

As in van Leeuwen and Lachmann (2004, Exp. 4), we used 24 unique stimuli: the four capital letters *A*, *H*, *L*, *C*; and the four geometrical shapes square, triangle, rectangle, circle, each of which was shown either in isolation or surrounded by a congruent or incongruent non-target geometrical shape. For instance, *A* in isolation, *A* surrounded by a triangle (congruent condition), *A* surrounded by a rectangle (incongruent condition).

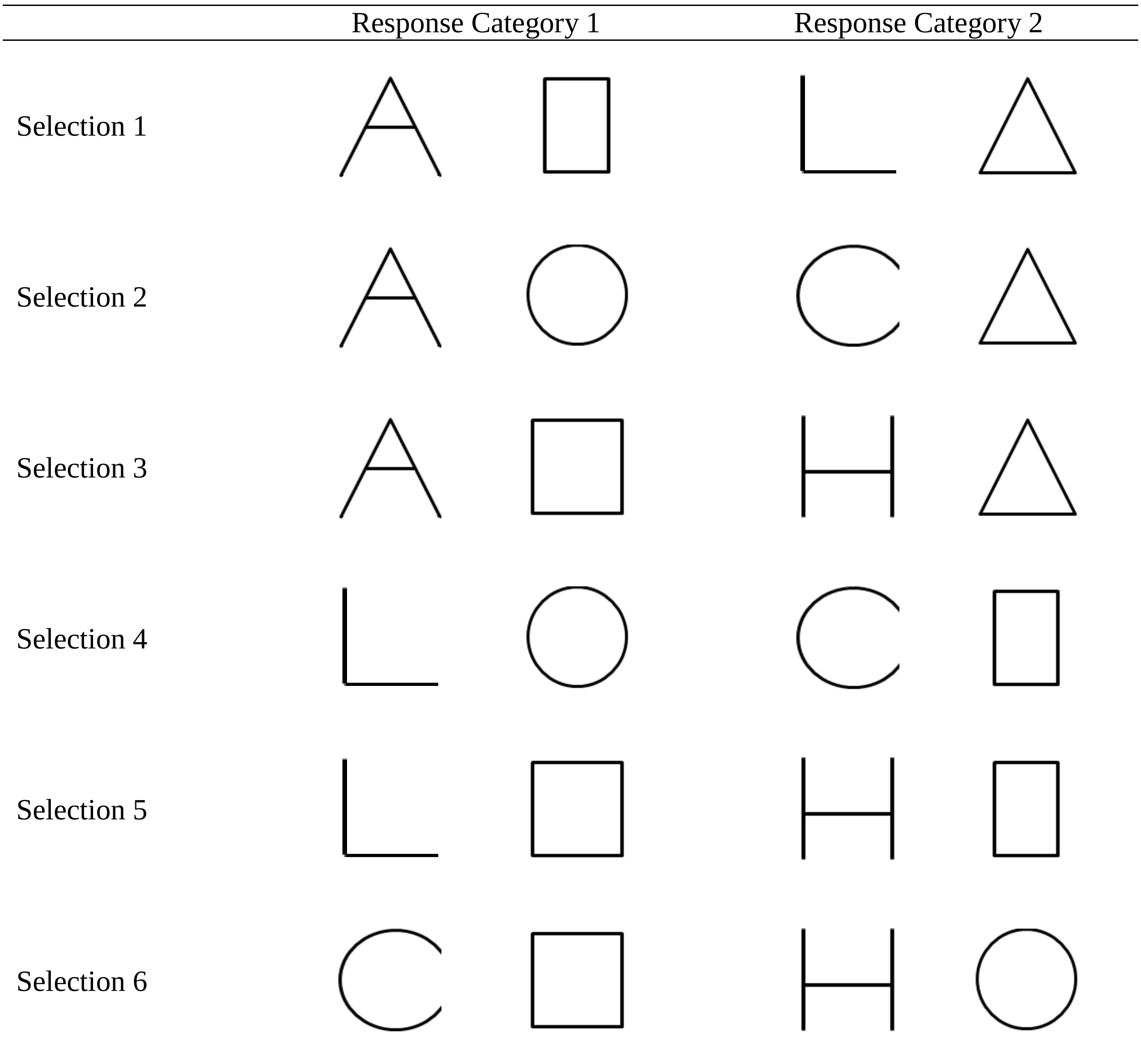

Fig. 1. Six selections of stimuli used in the experiment for individual participants. Further explanations in the text.

As in the 2004 experiment, six subsets of stimuli were presented to the participants in a counterbalanced fashion (Fig. 2). For each individual, the stimuli were restricted to two letters and two shapes. Letters and shapes were pair-wise similar in visual form, e.g. an *A* and a triangle. They were assigned in a counterbalanced manner to two different response categories: For instance, Category 1: "*A* or a Rectangle" versus Category 2: "L or a Triangle". Note that letters and shapes that are similar to each other in shape, such as the *A* and the triangle, were always assigned to different response categories. Thus, in order to solve the task, phonological coding of the letters is useful to distinguish between response categories, but is not necessary. In skilled readers this design was found to implicitly require a distinction between letters and shapes (see Table 1, results from van Leeuwen & Lachmann, 2004).

Table 1: Results from van Leeuwen and Lachmann, Exp 4. (2004).

			Reaction Time (msec)	
Targets	Context	Congruence	*M*	*SD*
Letters	Isolated		464.0	120.0
	Surrounded	Congruent	475.0	123.1
		Incongruent	468.5	119.1
Shapes	Isolated		480.7	133.2
	Surrounded	Congruent	484.9	128.3
		Incongruent	491.5	131.1

A speeded choice reaction task (4 targets x 3 conditions: isolated, congruent surrounding, incongruent surrounding, 60 repeated measures) was required according to the response categories displayed in Fig. 2, by pressing either the left or the right bottom marked on the keyboard of the computer lap top. The four stimuli were shown to the participant prior to the experiment and it was marked for what two stimuli, e.g. A and square, the left and for what, e.g., L or triangle, the right bottom press was required. It was emphasized that the surrounding, if it occurs, is not relevant for the task and should be ignored.

Results and Discussion

Results for both groups in Lachmann et al. (2011) are displayed in Fig. 2. Even though both groups in this study consisted of Indian adults, they are likely to differ in more than their ability to read; such as in general intelligence, education, language skills and in their familiarity with computers, which all may have influenced their performance. In particular, the latter factor may be responsible for the considerably higher over-all reaction times in illiterates, when compared to literates, both in the earlier and the present study. Such differences are probably inevitable in this kind of studies. However, the pattern of results, in particular that we found literates to show the same effects as literates in earlier studies whereas illiterates were found to show no differentiation in processing between letters and non-letter shapes suggests that congruence effects are influenced by literacy.

Illiterates not only processed letters and shapes equally over all, i.e., there was no letter-superiority effect, they also showed for both materials the same preference for items presented in isolation versus in surrounding, as well as the same effects of irrelevant surrounding congruence. For both letters and non-letters, incongruent surroundings were preferred over congruent ones. In contrast, literates of the same ethnicity differentiated between letters and non-letters, just as skilled readers from Germany and Japan did (Lachmann and van Leeuwen, 2004; Jincho et al., 2008). They showed a letter superiority effect: letters are processed faster than non-letters and produced opposite congruence effects for letters versus non-letters: a positive congruence effects for non-letters and a *negative* congruence effects for letters (see Fig. 2).

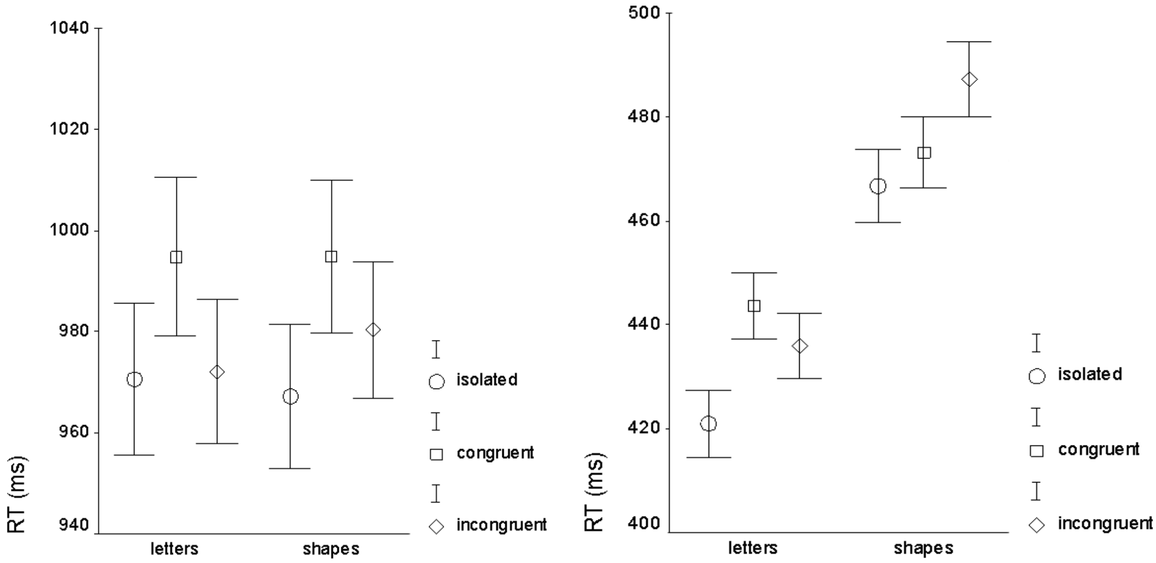

Fig. 2. Results from Lachmann, Khera, Srinivasan and van Leeuwen (2011).

The negative congruence effect in illiterates, i.e. their preference for incongruent surroundings, implies that an analytic perceptual strategy prevailed. Developmental studies might have led us to expect that before reading is automated, at least in an age up from six years on, a holistic strategy to predominate. Lachmann and van Leeuwen (2008) compared adults with different groups of children: beginning normal readers from Grade 3 and 4, and age matched developmental dyslexics. Most of these children showed positive congruence effects for both letters and non-letters, indicating holistic preference. One reason could be that certain brain functions related to reading, especially auditory processing (Banai & Ahissar, 2006) are still developing at this age. This may keep them from using an analytic letter processing strategy that would enable rapid grapheme to phoneme encoding.

A subgroup of dyslexic children in Lachmann and van Leeuwen (2008), with particular difficulties in reading non-words, however, shows particularly strong negative congruence effect for letters. This suggests that at this stage in development the analytic strategy at least is present, even though, for object recognition and face recognition, the holistic strategy became already dominant (Schwarzer, 2002). The results in dyslexics, therefore, are not inconsistent with those of illiterates: The negative congruence effects in illiterates means that analytic processing is not a reading-specific, secondary differentiation in perceptual organization that accompanies the process of learning to read. Rather, it is a generic and primary perceptual processing strategy, on a par with the holistic strategy. Skilled reading recruits this general perceptual strategy for letter recognition, and uses it in a coordinated fashion along with other functions, including phonological, cognitive, motor and attentional ones, in meeting the specific demands of reading. What is specific to skilled reading is not the automatization of a letter-specific perceptual strategy, but the automated coordination of various functional components in their specific combination (Lachmann et al., 2011). In this process, letter processing becomes tied up with the analytic perceptual processing strategy. As a result, adult readers no longer show the ability to process simple non-letter objects analytically. This result is in accordance with the pervasiveness of congruency effects in visual object perception (Boenke et al, 2009; Erikson & Schultz, 1979; Pomerantz, Pristach & Carson, 1989). In incongruent conditions, observers fail to ignore irrelevant information, even if this would facilitate processing. This effect is usually considered a result of attentional interference of the irrelevant flanking or surrounding information; this remains a puzzle if we consider that, in principle, focused attention could have been applied to the target (Miles & Proctor, 2010). The present study suggests that this is because analytic processing has preferentially become associated with reading. Despite this, having learned to read does not render entirely impossible the analytic processing of non-letter shapes. Evidence of analytic processing is not restricted to letters; negative congruence effects, although sparse, are found whenever active suppression of surrounding information is needed to distinguish a target (Bavelier et al., 2000, Briand, 1994; van Leeuwen & Bakker, 1995). The fact that these conditions are rare suggests that the differentiation that associates holistic processing with non-letters and analytic processing with letters is, by and large, effective.

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