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Cognitive Complexity and Attentional Control in the Bilingual Mind

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In the analysis and control framework, Bialystok identifies analysis (representation) and control (selective attention) as components of language processing and has shown that one of these, control, develops earlier in bilingual children than in comparable monolinguals. In the theory of cognitive complexity and control (CCC), Zelazo and Frye argue that preschool children lack the conscious representation and executive functioning needed to solve problems based on conflicting rules. The present study investigates whether the bilingual advantage in control can be found in a nonverbal task, the dimensional change card sort, used by Zelazo and Frye to assess CCC. This problem contains misleading information characteristic of high-control tasks but minimal demands for analysis. Sixty preschool children, half of whom were bilingual, were divided into a group of younger ($M = 4{,}2$) and older ($M = 5{,}5$) children. All the children were given a test of English proficiency (PPVT-R) and working memory (Visually-Cued Recall Task) to assure comparability of the groups and then administered the dimensional change card sort task and the moving word task. The bilingual children were more advanced than the monolinguals in the solving of experimental problems requiring high levels of control. These results demonstrate the role of attentional control in both these tasks, extends our knowledge about the cognitive development of bilingual children, and provides a means of relating developmental proposals articulated in two different theoretical frameworks, namely, CCC and analysis-control.

INTRODUCTION

A series of studies investigating the metalinguistic development of monolingual and bilingual children, conducted from the perspective of a framework for the development of representations (Bialystok, 1993), has revealed consistent developmental patterns for these two groups. The framework identifies changes in mental representation that lead to an increasingly metalinguistic and literate use of language by children. These representational changes are attributed to the development of two processing components. The first, analysis, is the ability to represent increasingly explicit and abstract structures; the second, control, is the ability to selectively attend to specific aspects of a representation, particularly in misleading situations. Together, these two processes enable children to move from simple conversation to intentional language use involved in reading (Bialystok, 1988a) and metalinguistic problem solving (Bialystok, 1986).

In normal development, children progress incrementally in both the analysis that is responsible for increasing the explicitness of representations and the control that is responsible for intentional selection and attention. Moreover, these processes are related: The availability of more explicit representations permits the execution of higher levels of attentional control. The methodological problem in investigating this conceptualization is in disentangling the two. Bilingualism presents an important forum for this endeavor. If the experience of learning more than one language in childhood changed the way in which one of these processes evolved, then it would be possible to observe their developmental effects individually.

The research approach has been to present children with versions of tasks that alter the balance in which the two processes are required for the solution to a problem. For example, a grammaticality judgment task consisting of simple well-formed sentences can be manipulated to increase the individual involvement of analysis and control. A standard sentence, such as, “Why is the dog barking so loudly?” makes few demands on either the abstractness of representational structures or the control of attentional processes, and children easily recognize it as an acceptable sentence. The demands for analysis are increased by introducing grammatical errors to the sentence, such as, “Why the dog is barking so loudly?” Children need to detect the violation in structure and respond that the sentence is unacceptable. The demands for control are increased by introducing distracting information that is irrelevant to the solution, such as, “Why is the cat barking so loudly?” Children are trained to respond only to grammaticality, but the error in meaning is a compelling magnet for their attention and it is difficult to respond that these sentences are grammatically correct.

A consistent finding in this research is that bilingual children perform better than their monolingual peers in tasks that demand high levels of control, but

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there is no bilingual advantage in tasks for which the solution relies primarily on high levels of analysis of representational structures (Bialystok, 1986, 1988b, 1997). On the grammaticality judgment task described above, correct solutions to the analysis problem (grammatically incorrect but meaningful) increased with the acquisition of literacy for both monolingual and bilingual children with no difference in improvement between them. In contrast, the control problem (grammatically correct but anomalous) is solved better by bilingual children. Recent studies have tentatively extended the pattern of a bilingual advantage for high-control tasks to development in nonverbal problem solving (Bialystok & Majumder, 1998) and numeracy (Bialystok & Codd, 1997). These studies also replicate the finding that there is no bilingual advantage for high-analysis tasks.

One can do no more than speculate as to why bilingual children find it easier to resist distraction than monolinguals. Clearly, bilingual children routinely pay attention to abstract dimensions of language that are essentially transparent to monolingual children. Bilingual children need to be aware at some level (but not necessarily consciously) of the language that is needed in a particular situation or with a particular speaker, and they rarely make mistakes in selection (De Houwer, 1990; Genesee, 1989, Meisel, 1989). They also realize that names for things are arbitrary because they can call the same thing by different names, reinforcing the distinctiveness between words and their meanings (Ianco-Worrall, 1972; Vygotsky, 1962). These kinds of experiences may help bilingual children to make the forms of language more salient, to represent them more explicitly, and to resist distraction to the irrelevant dimensions. What is more interesting but less obvious is the extent to which this ability extends beyond the domain of linguistic processing.

One approach to help clarify the selective attention advantage for bilingual children is to determine the range and nature of problems in which this advantage occurs. It would be particularly helpful if the advantage could be demonstrated in problems that were rooted in a theoretical context because the mechanisms in that theory could be evaluated for their explanatory role in describing the performance of bilingual children. In addition, demonstrating the effect for nonverbal problems would help to explicate the cognitive underpinnings of the bilingual advantage because it could not be simply attributed to a greater knowledge of language itself.

One problem that is potentially useful in this regard is a task developed by Zelazo and his colleagues. The problem, called the dimensional change card sort task, places two pairs of rules in conflict and requires children to pay attention to one of them at a time (Frye, Zelazo, & Palfai, 1995; Zelazo, Frye, & Rapus, 1996; Zelazo & Jacques, 1996, for review). Children are shown cards containing pictures of two targets, for example, a red rabbit and a blue boat. They are then given a set of cards consisting of red boats and blue rabbits and required to sort them by one of the dimensions, color, or shape. Following this, a new pair of rules reverses the relationship between the targets and the cards and children must sort the cards by the opposite dimension. Until 4 or 5 years of age, it is very difficult for children to succeed in the second phase (postswitch) when the sorting rule changes because they continue to use the first rule.

Zelazo and Frye (1997) explain children's failure to solve this problem in terms of the Cognitive Complexity and Control (CCC) Theory. In this view, children increase control over their behavior as they acquire increasingly complex rule systems (described as consciousness) and reflective awareness of those rules (described as executive functioning). Consciousness is defined as the extent to which the representation of rules is sufficiently explicit to allow reflection and control. Following Tulving (1987), they assume that conscious memory systems are ontogenetically (and phylogenetically) more advanced than unconscious ones. Therefore, young children fail the CCC tasks because they lack the conscious representations that would allow them to keep the new rules in mind (e.g., Goldman-Rakic, 1990). An important account of how representations can become more conscious is proposed by Karmiloff-Smith (1992) through a mechanism she calls representational redescription.

Executive functioning is needed to bring intentional selection to problem solving. Executive accounts assume a hierarchically organized process that requires reflective awareness to operate intentionally and an inhibition mechanism to suppress the more automatic responses of the lower levels. The development of inhibition is particularly crucial to the tasks used in the CCC because the solutions typically require overcoming earlier responses. The development of inhibition processes in young children has been well documented (e.g., Dagenbach & Carr, 1994; Tipper, 1992). Beginning with Luria (1961), the need for inhibition has been recognized as a crucial component of executive functioning. Luria's (1973) localization of inhibition in the prefrontal cortex not only reinforced its theoretical role in cognitive functioning but also solidified its practical importance by connecting it to known cortical centers. More recent research has traced the development of the inhibition function and connected it to important changes in problem solving (Dempster, 1992; Diamond, 1991; Harnishfeger & Bjorklund, 1993).

The dimensional change card sort task requires both types of processing. Higher order rules are needed to make deliberate decisions about lower order rules, so conflicting situations only can be handled once the higher order rules have been learned. In the absence of a higher order rule to resolve the conflict, children rely on the associative strength of a particular rule. Associative strength is greater for the first rule that was used, so children persist in responding according to the rules for the first dimension given. The young children who commit these errors cannot modify their responses because they fail to see that the second set of rules is simply another version of the one they have already learned. Solving the problem, therefore, requires both representing the information at a higher level of abstraction (consciousness) and using that higher order rule to direct behavior and inhibit a more salient alternative (executive control).

In addition to the dimensional change card sort task, the theory has been investigated using tasks based on children's understanding of object sorting (Zelazo & Reznick, 1991; Zelazo, Reznick, & Pinon, 1995), physical causation (Frye, Zelazo, Brooks, & Samuels, 1996), and theory of mind (Frye, Zelazo, & Palfai, 1995). Although these tasks involve reasoning in different domains, they are similar in that a conflict is established between rules that apply under different conditions. Children are able to learn the first rule, or pair of rules, but fail the task when the rules are altered. What is difficult, then, is to alter their response to a stimulus when the change contradicts an initial value, for example, considering a blue rabbit to be a blue thing after having treated it as a rabbit.

These problems may provide a means of expanding the results obtained from the analysis and control framework and also evaluate some of its theoretical claims. The need for conscious representation in the CCC is similar to the development of analysis of representations and the requirement for executive control is reminiscent of the emergence of control of attentional processes. In the dimensional change card sort task, the demand for analysis is in the ability to understand the scope of the sorting rule and the demand for control is in the ability to ignore the original rule and reconsider the cards in terms of the new instruction. The control demand is clearly the more challenging, because children rarely make an error in the first half of the task (in which they simply follow a rule) but encounter great difficulty in the second half (in which they must ignore the first rule and attend to a different dimension). If this analysis is correct, then bilingual children should solve the dimensional change card sort task better than monolinguals.

Evidence from bilingual children also will allow a comparison of the two developmental descriptions. In both theories, development proceeds, to some extent, by means of advances in representational explicitness and attentional control. In the CCC, these two aspects of processing are interdependent; in the analysis-control framework, they are theoretically separable. Testing children with tasks whose developmental properties are known from each theory will provide a means of assessing some of the claims of both theories and evaluating their compatibility. The moving word task is a control task in which bilinguals have repeatedly shown an advantage (e.g., Bialystok, 1997). If the dimensional change card sort task assesses the same underlying processes, then the developmental pattern for the two tasks will be the same. The results may also shed light on the separability of the processing components involved in each description.

METHOD

Participants

The study included 60 children divided equally into two age groups. The 30 children in the younger group ranged in age from 3,2 to 4,9; those in the older group ranged from 5,0 to 6,3. In addition, the children represented two linguistic groups. Half of the children were monolingual speakers of English (16 boys and 14 girls). This group included 15 younger (M = 4,3) and 15 older (M = 5,5) children. The remaining children were bilingual speakers of English and Chinese. These children spoke Cantonese or Mandarin at home but English in the community and at school. Hence, they were fluent in Chinese but differed in their mastery of English. A Peabody Picture Vocabulary Test–Revised (PPVT-R; see below) was used to assure that the children in the final sample had English proficiency comparable to that of the monolinguals and were therefore fully bilingual. This group also included 15 younger (M = 4,1) and 15 older (M = 5,5) children. Eleven additional bilingual children were not included because their English was too limited.

All the children were recruited from childcare centers in a middle-class urban area. The monolingual and bilingual children often attended the same centers. Parents and childcare supervisors confirmed the children's status as monolingual English or bilingual Chinese-English when granting permission for the child's participation in the study.

The childcare centers were structured like kindergarten classes. None of the children in the study had yet entered 1st grade, so none of the children had received any formal instruction in reading. Nonetheless, teachers were asked to confirm that the children included in the study were not yet able to read independently.

Tasks and Procedures

Children were tested individually in two sessions, approximately 1 week apart. Each session lasted about 15 minutes. In the first session children were given the PPVT-R, Form M (Dunn & Dunn, 1981), and the Visually-Cued Recall task (Zelazo, Burack, Jacques, & Frye, 1997). The second session consisted of the Moving Word Task (Bialystok, 1991, 1997), and the Dimensional Change Card Sort Task (Zelazo et al., 1996).

Peabody Picture Vocabulary Test–Revised (PPVT-R). This is a standardized test of receptive vocabulary. Children were shown a card containing four different pictures and asked to indicate (either verbally or by pointing) which picture best depicts a word given orally by the experimenter. A basal score was established and testing continued through increasingly difficult items until the child made six errors in eight consecutive responses. Standardized tables are used to convert raw scores to percentiles, stanines, and standard scores. All three were computed for the present study, but the results are reported only for the standard scores.

The test was administered in English to all children in the study. One purpose of this was to establish that all the children were functioning at a normal level of cognitive ability for their age. Receptive vocabulary is often used as a rough indicator of general intelligence. The second purpose was to confirm that the bilingual children had English proficiency that was comparable to that of the monolinguals, both verifying their status as bilingual and demonstrating sufficient competence in English to understand the task instructions. As all the bilingual children spoke Chinese at home, no test was given for Chinese proficiency.

Visually-Cued Recall Task. This task was used to assess the child's memory span. The intention was to establish that the children in the two groups were comparable in a cognitive assessment of working memory and, by proxy, roughly equivalent in intelligence. As with the PPVT-R, the purpose was to assure that children were equivalent in their relevant initial abilities.

A series of posters (36 cm $\times$ 66 cm) was shown to the child. Each poster contained 12 different pictures of familiar objects. A toy cat was introduced and the experimenter told the child that the cat liked certain things on the poster. The cat then pointed to specific pictures and the experimenter named each selected object. When the cat finished, the child was asked to point to the things that the cat liked. Each poster increased the number of items selected by the cat, beginning with one item and continuing until the child made errors on two consecutive posters. The order in which the child recalled the selected items was not important.

Each poster was scored for the number of items accurately recalled, number of items added in error, and number of items deleted. The test score was the *total* number of pictures correctly recalled *across all the posters* examined. Therefore, two different children could both reach the seventh poster before testing stopped (because there were errors on both the sixth and seventh posters) but achieve different test scores because a different correct total was obtained on some of the posters. If a correct poster followed a poster with an error, the testing continued and the child continued accumulating points for the items correctly recalled, even on the incorrect poster. Hence, the score is more sensitive to the child's memory performance than that obtained in a digit span test in which only final digit length is recorded. The prediction was that older children would recall a greater number of items than younger children but that there would be no difference in performance between the two language groups.

Moving Word Task. This task assesses the child's understanding of the invariance of symbolic relations. Two toy bunnies were introduced. The experimenter then showed the child two pictures of common objects, for example, a king and a tree, and named them. A card with the name of one of the pictured objects printed on it was brought out and the experimenter told the child what the card said. The experimenter placed the card under the picture of the named object and asked the child what the card said (*introductory question*). The child's attention was then distracted by the bunnies who began a scuffle and "accidentally" kicked the card so that it was under the wrong picture. The child was asked for the second time what the card said, but this time the card was under the wrong picture (*inconsistent question*). Finally, the experimenter drew the child's attention to the mess that the bunnies had made and said it must be tidied up. The card was moved back under the original picture and the child was asked for the third time what the card said (*consistent question*). As the card was being moved back and forth, there was no discussion of the pictures nor was the child's attention explicitly drawn to them. Three such sequences were presented to each child, using different picture pairs and word cards on each. Children received a point for each question correctly answered, cumulating into a score out of 3 (because there were three trials) for each of the introductory, inconsistent, and consistent questions.

The task assesses the child's ability to selectively attend to the relevant information, in this case, the word card, without being distracted by the picture. The task is difficult because the child's attention is almost irresistibly drawn to the picture because it initially corresponds to the named word and children find it difficult to ignore that information. Bilingual children have previously been shown to excel in this task (Bialystok, 1997).

Dimensional Change Card Sort Task. This task was developed by Zelazo and his colleagues (Zelazo et al., 1996) to assess the co-ordination between knowledge and action in young children. Children are required to sort a set of laminated cards (8 cm $\times$ 8 cm) into two groups on the basis of a perceptual feature of the displayed items and then to resort the same cards on the basis of a different feature. In the set of cards used in the present study, each card portrayed a circle or square that was red or blue. Half the children began with instructions to attend to the shape and the other half to the color.

A card sorter containing two compartments, each large enough to hold the cards, with a stand behind each compartment, was placed on the table in front of the child. A target card was affixed to each stand. The target cards showed, for example, a red circle and a blue square. The cards to be sorted in this case would include five red squares and five blue circles.

In the first phase of the task, preswitch, the experimenter pointed to the target cards and explained the rules of the game according to the relevant dimension. For example, if the preswitch phase used the color rules, the experimenter said: "This is the color game. In the color game, the red ones go here and the blue ones go in this box. This is the color game, so we don't put any red ones here; the red ones go here and the blue ones go here." There was a single training trial to sort one card with feedback, followed by the remaining 10 cards. Each card was placed face down in the tray as it was sorted. The experimenter repeated the rule as she handed the child each card: "Remember, the red ones go here and the blue ones go here."

The second phase was postswitch. The target cards remained the same but the experimenter told the child that they were now going to play a new game, and explained the rules again using the opposite feature, in this case, shape. The same explanation was given, substituting the shape names for the color names: "This is the shape game. In the shape game, the circles go here and the squares go in this box." Again, the child was given 10 cards to sort.

The final phase was called knowledge-action. Children were asked about their knowledge of the rules and then assessed for their ability to sort the cards according to this knowledge. Using the dimension from the postswitch phase, the experimenter said, "Remember, in the color (shape) game, all the red ones go in this box and all the blue ones go in that box? Where do the red ones go in the color game?" "Where do the blue ones go in the color game?" The child was then given a card and told, "Play the color (shape) game. Where does this card go in the color (shape) game?" This procedure was repeated three times, so the child sorted three different cards.

Children received a score out of 10 for the number of cards they correctly sorted in the preswitch phase, another score out of 10 indicating their success in the postswitch phase, and a score out of 3 for the three sorting trials (action) in the knowledge-action phase. The responses to the knowledge questions in the knowledge-action phase were recorded but not analyzed as there were no errors. The recorded data for this part of the task are from the action questions in which children placed the designated card in the appropriate compartment.

RESULTS

PPVT-R and Visually-Cued Recall Tasks

The *mean* standard scores (and *SD*) on the PPVT-R for the monolinguals were 102.2 (15.9) for the younger children and 98.2 (18.0) for the older ones. The results for the bilinguals were 92.3 (11.6) for the younger children and 96.6 (7.3) for the older group. A two-way analysis of variance (ANOVA) for language and age found no significant effect for either factor or for the interaction between them. The results of the ANOVA are the same if the stanine or percentile scores are used.

In the visually cued recall task, the *mean* scores (and *SD*) for the monolinguals were 16.20 (11.20) for the younger group and 21.20 (8.8) for the older. For the bilinguals the results were 16.40 (9.1) for the younger group and 21.73 (5.4) for the older. A two-way ANOVA for age and language showed a significant effect of age, $F(1, 58) = 5.09$, $p < .03$, but no effect of language and no interaction between them.

Moving Word Task

In the moving word task, children received a score out of 3 for each of the introductory, inconsistent, and consistent questions. In the introductory question, only one child, a young monolingual, made an error on one item. Hence, the *mean* score for these items by

Table 1 Mean Number Correct out of 3 (and *SD*) in Moving Word Task for Inconsistent Item

	Age		
Language	Younger	Older	*Mean*
Monolingual	1.60 (1.12)	2.13 (1.12)	1.87
Bilingual	2.13 (1.24)	2.80 (0.41)	2.46
Mean	1.87	2.46	

Table 2 Mean Number Correct (and *SD*) in Card Sort Task for Postswitch and Knowledge Items

		Age		
Item	Language	Younger	Older	*Mean*
Postswitch (Out of 10)	Monolingual	3.33 (3.62)	8.06 (2.89)	5.69
	Bilingual	6.93 (3.66)	9.53 (1.12)	8.23
	Mean	5.14	8.79	
Knowledge (Out of 3)	Monolingual	1.06 (1.43)	2.46 (1.06)	1.76
	Bilingual	2.06 (1.27)	3.00 (0)	2.53
	Mean	1.56	2.73	

the younger monolinguals was 2.93 ($SD = .25$); all other scores for these items were 3.00. Similarly, the consistent question elicited practically perfect performance. The younger monolinguals achieved a *mean* score of 2.53 ($SD = .83$) and the younger bilinguals, 2.87 ($SD = .35$). Both groups of older children obtained a *mean* score of 2.93 ($SD = .25$) on these items. A two-way ANOVA conducted on each of these sets of scores confirmed there were no significant effects and no interactions.

The relevant data for this task come from the second question, the inconsistent item. The *mean* score on the inconsistent question by age and language are reported in Table 1. There were equal advantages for both age, $F(1, 58) = 5.09$, $p < .02$, and bilingualism, $F(1, 58) = 5.09$, $p < .02$, with no interaction between them.

Dimensional Change Card Sort Task

The card sort task was scored by assigning a value for each of the three phases: pre-switch (out of 10), postswitch (out of 10), and knowledge-action (out of 3). In their research with this task, Zelazo and colleagues (1996) classified children as either passing or failing each phase on the basis of a criterion of 80% correct to pass or 80% incorrect to fail. It was decided to use distributed scores, however, in order to observe more gradual development and to compare performance across the tasks.

Children made virtually no errors in the preswitch phase. The only group not to achieve a perfect *mean* score of 10.00 was the older monolinguals, whose *mean* score was 9.87 ($SD = .35$). The scores for the postswitch phase are reported in Table 2. A two-way ANOVA again showed advantages for age, $F(1, 58) = 17.57$, $p < .001$, and bilingualism, $F(3, 58) = 8.38$, $p < .005$, with no interaction between them. The same pattern was found in the knowledge-action phase: there were effects for age, $F(1, 58) = 16.91$, $p < .001$, and language, $F(1, 58) = 7.30$, $p < .005$, with no interaction. These data also are displayed in Table 2.

Following Zelazo et al. (1996), a modified classification for passing or failing was applied to the postswitch phase of the card sort task by the criterion of 80% correct performance. Each child who sorted at least 8 of the 10 cards correctly was considered to pass, and those who scored less were considered to fail. Using these criteria, the monolingual group consisted of 15 children who passed and 15 children who failed, and the bilingual group included 23 children who passed and 7 children who failed. The chi-square analysis shows that the distribution is significantly different from chance, $\chi^2(1, N = 60) = 4.06$, $p < .03$.

It is possible for two tasks to elicit similar patterns of performance without there necessarily being a relation between the tasks. Accordingly, a correlation analysis was conducted to assess the degree of overlapping variance in the inconsistent question on the moving word task and the postswitch phase of the card sort tasks. These are the two primary dependent measures and the two scores in which there was a bilingual advantage. The correlation between these scores was significant, $r = .37$, $p < .004$. The correlation remained significant when PPVT-R scores were partialled out, $r = .39$, $p < .002$, and when Visually-Cued Recall was partialled out, $r = .37$, $p < .004$, strengthening the claim that the two tasks directly share variance rather than reflecting the effect of a mediating variable.

DISCUSSION

All the children in the study were shown to have equivalent levels of receptive vocabulary (PPVT-R) and comparable capacity for working memory (Visually-Cued Recall). Both these measures indicate a general equivalence of intelligence. Moreover, the children had similar backgrounds and attended the same schools. Therefore, performance differences between the groups could not be attributed to differences in

English proficiency, memory span, or preschool experience. Nonetheless, on tasks in which distracting information made the solution difficult, bilingual children were more skilled than monolinguals. These results replicate earlier research and add empirical support to the proposition that bilingual children are privileged compared to their monolingual peers in their ability to solve problems that are based on conflict and attention. In the present study, the bilingual advantage emerged in a nonverbal sorting task that appears to have no connection to linguistic competence.

The main dependent measures in the study, the moving word task and dimensional change card sort task, presented children with a conflicting situation. In both cases, a criterion for responding that was successful in the first part of the problem becomes obsolete following a change (position of the card for moving word and rule for card sort). Children must reconsider their response in view of this change. In the moving word task, the change is irrelevant and children need to realize that the meaning of the printed word has not been affected by the change in position. Thus, the solution requires recognition of the stability of a response across changes in the display. In the dimensional change card sort task, the change is crucial to success in the second phase. This solution requires recognition of the relevance of the new rule and the ability to resist persisting in the previous behaviors.

This difference between the tasks makes it possible to examine the viability of alternative explanations for solving the card sort problems. Zelazo and colleagues (1996) had considered the possibility that the problem was difficult because children had overlearned the first response and could not break away from the familiar pattern. To test this proposal, they presented the task using a single trial in the preswitch phase, assuming that one trial would be insufficient to establish an overlearned response. They found that children still perseverated on the preswitch rule, precluding the possibility that overlearning was the reason for the fixation.

The present results endorse this conclusion that overlearning is not the cause of children's failure. Whereas perseveration leads to errors in the card sort task, it leads to success in the moving word task: the same children who could change their response through phases of the card sort task could maintain their response through trials of the moving word task. If these tasks are based on some measure of common processing, as suggested by the correlation between them, then that process must be construed at a sufficiently general level to accommodate this difference between the tasks. It is unlikely, therefore, that performance is the result of fixating on established responses because that could explain the results of only one of the two tasks. What is common is that both tasks require children to resist attending to a salient dimension of the problem space and intentionally focus on some other dimension.

In the CCC model, this ability to intentionally focus attention is explained through reflective awareness and inhibition in executive functioning. However, children can only solve the problem when they have represented the rules in a hierarchy that includes explicit and conscious representation. In the analysis-control model, control of attention is one of the two processes invoked in problem solving. Whereas the CCC confers two kinds of advantages on bilingual children, the analysis-control framework confers only one.

Is there any evidence that bilingual children differed from monolinguals in their representation of the problem? For CCC, the problems cannot be solved in the absence of the described levels of representation, so it is inferred that such representations are part of the repertoire of the successful children. In the analysis-control framework, demands for representational explicitness are placed on a graduated scale. For example, judging the grammaticality of a sentence requires very low levels of analysis, identifying the error involves a more explicit representation, and correcting the error increases the analysis demands further. In these terms, the analysis demands on both the card sort and moving word task are very modest. Moreover, the pattern of a bilingual advantage on problems requiring high control but low analysis is consistent with previous research (e.g., Bialystok 1988b, 1997). The success of the bilingual children in the two tasks in the present study makes it at least plausible that the two aspects of functioning under the CCC are distinct, since there is no reason to attribute more sophisticated representations to bilingual children than are available to monolinguals.

To test the limits of the bilingual advantage, it would be necessary to modify the tasks so that some versions required more complex representations. For these tasks, the analysis-control framework would not predict any bilingual advantage but the CCC would expect the bilinguals to continue to demonstrate superiority because the representation of the higher order rule is part of the same function as the reflective awareness and inhibition needed to solve the problem. The representations may be made more difficult in the card sort task by using classifying dimensions that were more abstract or more complex, for example, by including more information or more rules.

Another difference may be in children's ability to explain what was happening in the problem: presumably more explicit representations would enable children to produce more accurate descriptions of the problem.

What is the bilingual advantage and why do they have it? Consistent with previous research, the advantage is demonstrated in situations of conflict and distraction. The present study extends this claim in two ways. First, empirically, the present results have provided evidence of the ability of bilingual children to exercise control over attention in a problem that is nonverbal and based on different forms of problem solving than any previously used. This replication adds important data to the repertoire of abilities that are affected by bilingualism. Second, theoretically, the incorporation of bilingual performance into an established theoretical account of development in problem solving enhances the explanatory possibilities for understanding how bilingualism affects development. Presuming it is in the executive functioning aspect of the CCC that the bilingual children demonstrated their greater skill, then it follows that bilingualism in some way impacts on the development of executive functioning. This is potentially an important claim, because of the place of executive functioning in accounts of learning and cognition. The results also suggest that a fruitful direction for further research would be to explore the development of an inhibition mechanism in bilingual children. Moreover, executive functioning has been studied from the perspective of neuropsychology, and it is conceivable that the effects of bilingualism eventually will be available to inspection by functional neurological measures. Frontal lobe activity would be an obvious locus for investigation. What is not at all clear at this time is why the experience of speaking two languages from childhood manifests itself in these profound ways in cognitive development.

Both the moving word task and the dimensional change card sort task have been well researched and have produced consistent replications over different populations. The present results replicated previous research with the individual tests. The contribution of the present study is in providing a new perspective on the interpretation of these tasks by revealing an underlying similarity in their logic (as evidenced by the correlation between them), enriching the explanation of how each is solved (by relating it to concepts developed for the other problem), and identifying an important experience that enhances development of the relevant processes (bilingualism).

The study also has helped to advance thinking in both the CCC and analysis-control paradigms by bringing new data to bear on the models that both replicate and extend previous findings in systematic ways. The direction that this leads is toward more domain-general conceptions of development. It is entirely reasonable that the cognitive advances made by children in the preschool years across the various domains of understanding are not fuelled by isolated mechanisms, in individual ways, with independent outcomes. Rather, it is more sensible to believe that children's development is organized and systematic, and it proceeds in ways that are recognizable and consistent.

Finally, the study adds a new dimension to the understanding of how a specific experience, namely, learning two languages in childhood, influences important aspects of children's development. Such issues have become increasingly relevant as educators, researchers, and policy makers come to acknowledge the overwhelming frequency of this situation. At the same time, bilingual children offer an important avenue for thinking about such fundamental theoretical issues as the relation between language and thought. Both these practical and theoretical outcomes are nurtured by studying bilingual children.

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