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# Attentional Control and Early Word Learning

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## Abstract

There has been increasing interest in the role of early attention in the context of word learning. There has also been growing interest in attentional differences between bilinguals and monolinguals. The present study examined the relationship between mutual exclusivity and attentional control by comparing bilingual children whose attentional control is relatively advanced to age-matched monolingual children. The novel adjective learning paradigm was the word-learning measure and the Attention Network Test was the measure of attentional control. Three-year-old monolingual and bilingual children with similar vocabulary development participated. The results replicate earlier work on advanced attentional control among bilingual children and suggest that better performances in novel adjective learning by bilingual children might be due to attentional control. These findings support the importance of attention in early word mapping. The results add to a growing body of literature on the potential relevance of bilingualism in early word learning.

**Keywords:** Attentional learning; early word learning; adjective learning paradigm; mutual exclusivity; selective attention

## Attentional Shifting and Word Learning

A growing body of experimental literature (mostly concerning adults) indicates that effective attentional control optimizes learning, especially in complex scenes (e.g., Cowan, Fristoe, Elliot, Brunner, & Sauls, 2006). In the developmental literature, there has been interest in the role of effective attention shifting in learning, particularly in the domain of word learning. Because different kinds of words refer to different kinds of properties (e.g., nouns to shapes or whole objects, adjectives to properties such as color or texture), being able to shift attention seems an important aspect of word learning (Au, 1990). Indeed, a number of studies have documented that by the time children are 2 years old, they shift attention to different kinds of properties for different kinds of entities and in the context of different kinds of words (Graham, Williams, & Huber,

1999; Landau, Smith, & Jones, 1988, 1998; Soja, 1992; Soja Carey, & Spelke, 1991; Yoshida & Smith, 2003, 2005).

Some accounts of this effective attentional shifting refer to mapping principles for learning words (e.g., Bloom, 2000; Carey, 1978; Markman, 1989). One such principle is mutual exclusivity (Markman & Wachtel, 1988): In the context of a known word and referent, a novel word shifts attention to a novel referent. Mutual exclusivity is pervasive in early word learning, helping the learning of new nouns, but it has also been suggested as a reason why young word learners have difficulty learning adjectives (e.g., Carey, 1978; Markman, 1989; Regier, 1996). For example, young learners who know that a horse is called “horse” might reject the label “brown” being applied to it. This one label–one object constraint has long been considered a positive constraint on early word learning that promotes the learning of nouns. Also, it may help more advanced word learners learn adjectives. Older children, when challenged with two labels for a single object, will effectively shift attention to a nonshape property (if “horse” means HORSE, then “brown” must mean something about the horse; see Waxman, 2001; Waxman & Klibanof, 2000). Although the earlier view saw these constraints as lexically specific and possibly innate (Markman, 1989), more recent work suggests that the effect is related to learning through competitive attentional processes (Halberda, 2009; Hollich, Hirsh-Pasek, Tucker, & Golinkoff, 2000; Plunkett, 1998; Smith, 2000; Yoshida & Hanania, 2007).

If mutual exclusivity emerges because of competitive processes among words and referents that arise in on-line comprehension, then these processes—and their relation to effective attentional control in word learning—should be related to the learner’s history of experiences in resolving competitions among words and referents. This, in turn, suggests that the development of mutual exclusivity may benefit from bilingualism and attentional control more generally.

## Executive Control

Bilingual children have been characterized as developing cognitive flexibility earlier than monolingual children and demonstrating more robust self-control, including attentional control, throughout their lives (e.g., Bialystok, 1992, 1999; Bialystok & Martin, 2004; Bialystok & Senman 2004; Carlson & Meltzoff, 2008). Such positive effects are seen most profoundly in what are known as executive-function (or self-control) tasks. These are tasks that require the individual to inhibit preferred or prepotent patterns of responding (e.g., not jump up when one should be sitting, not take the candy when told not to, do a task in a new way not an old way; see Beaver & Wright, 2007; Kochanska, Murray, & Harlan, 2000; Luria, 1966; Luria, Pribram, & Homskaya, 1964; Mischel, Shoda, & Rodriguez, 1989; Zelazo & Frye, 1998). A number of recent studies have shown that these effects are also evident in executive function relevant to controlling attention and in the suppression and separation of languages to avoid interference. Indeed, the current consensus is that the bilingual advantage in executive control derives from the history of switching between languages (i.e., Costa, Hernandez, & Sebastian-Galles, 2008; Martin & Bialystok, 2003; Mezzacappa, 2004).

The idea that bilinguals are able to control the choice of their speech via well-developed processes of executive control is supported by their better performance in attentional tasks such as the Attention Network Test (ANT), which was developed by Fan, McCandliss, Sommer, Raz, and Posner (2002). This test was designed to measure the functionality of the attentional network: alerting, orienting, and executive control. Children are asked to find a fish facing a certain direction among other fishes on a computer screen. The direction the fish faces does not change throughout the task, but the facing direction of other fish does change and thus the task requires effective attention control. The response time for searching is often used to measure the attentional control. Costa et al. (2008) reported that bilinguals performed this task faster and more efficiently than monolinguals. Furthermore, when the task was broken down into the attentional network components, bilinguals performed significantly better in the alerting and executive control components. The bilingual advantage has also been reported in studies of bilingual children who have significantly lower English proficiency than the group of comparison English monolinguals (using ANT; Yang, 2004). This is an intriguing finding with a potentially widespread impact: Children who speak more than one language seem to show developmentally advanced attentional control.

What is not known is the extent of the advantage in attentional control or the role it plays in language

learning. If this advantage emerges in young bilingual children as a consequence of learning two languages, then it seems its core function might be to support language learning itself. The experiment reported here seeks to link differences in attentional control between monolingual and bilingual children to attention shifting in word learning, and more specifically to mutual exclusivity in the context of learning a novel adjective.

## Experiment

### Method

#### Participants

Participants were 20 monolingual English learners with a mean age of 36.66 months (range: 29.47 to 43.16) and 20 bilingual learners (e.g., English–Spanish, English–Bengali, English–Chinese, English–Russian, English–Urdu, English–Vietnamese) with a mean age of 38.86 months (range: 30 to 45.53). The criteria of bilingual status was determined by a demographic questionnaire. A bilingual questionnaire was used to ensure that the language spoken at home was primarily not English.

#### Stimulus Materials

*Vocabulary Assessment (MCIDI)* Eight sections from the MacArthur–Bates Communicative Development Inventories (MCIDI) were selected and used to measure productive vocabulary. For English monolingual children, the English version was used, and for bilingual learners, their dominant language (if reported by their parents) was measured. We also used the Spanish MCIDI. Adaptations of the MCIDI in Chinese and Vietnamese were used when possible. Monolingual children's total vocabulary was measured as the number of words parents reported in their productive vocabulary in English; bilingual children's total vocabulary was measured as the number of words parents reported in their dominant language (i.e., the language used most often by parent report).

*MacArthur Socioeconomic Status* Parents were asked to fill out a demographic questionnaire to control for the influence of socioeconomic status (SES) in bilingual and monolingual participants. All participants were matched and came from the same SES background.

*Novel Adjective Learning Task* Each of the eight trials in this task used three objects (one exemplar, two test objects); the objects in each trial were unique. All were instances of familiar animate objects (e.g., ducks) and inanimate objects (e.g., trucks) with distinctive colors. As shown in Figure 1, each exemplar was presented with a property that was highly novel (*sticky*). The two test objects for each trial had the same shape as the exemplar, but different colors. One test object presented

a target property match of the novel texture (e.g., red *sticky* duck), and one presented a non-property-matching texture (e.g., red *bumpy* duck). Within all trials, all objects—exemplars and test objects (property matching and non-property-matching)—had the same shape.

**Familiar Adjective Learning Task** The same three-dimensional object form was used for exemplars and test objects (e.g., ducks, trucks). The properties, familiar and likely to be receptively known by the children (e.g., bumpy, spotted, shiny, holey), can be seen in Figure 2. Two types of test objects were presented: one with a property match of a familiar/known texture (e.g., red *bumpy* duck), and one with a nonmatching property where texture did not match the exemplar (e.g., red *shiny* duck).

All objects were approximately 10 cm<sup>3</sup>. Textures—the intended target property—were chosen to be highly novel and included a stringy pattern, a wire pipe-cleaner surface, a sponge-like surface, and a Velcro surface. These properties were named by novel labels such as *blickish*, *dakish*, *talish*, and *wuggish*, respectively. For familiar textures, stimuli were *holey*, *shiny*, *bumpy*, and *spotted*.

**Attention Network Test (ANT)** We used the original "child version" of Dr. Jin Fan's ANT (<http://www.sacklerinstitute.org/users/jin.fan/>). The children were asked to watch a computer screen where five fish lined up horizontally. The task was to point to the mouth of the "hungry fish," which was defined as the fish always in the middle. The direction the hungry fish faced changed throughout the task, but the facing direction of other fishes changed. Children were required to shift their attention effectively to detect the direction of the hungry fish's mouth. We used a touch-screen laptop to measure accuracy in this task.

### Procedure

All children participated in the Novel Adjective Learning Task, Familiar Adjective Learning Task (control), and the ANT (in randomized order) in their dominant language; the task order was counterbalanced. Caregivers were asked to fill out the SES and MCDI forms. Parents of bilingual children were asked to fill out two MCDI forms, one in English and one in their second language. Parents were asked to go through the list and specify all the words they had heard their children use. The Novel Adjective Learning Task, Familiar Adjective Learning Task, and ANT trials were administered in a quiet, controlled room (both at the laboratory and at daycare centers) by trained research assistants fluent in the child's dominant language.

**Novel Adjective Learning Task** Participants were presented with an exemplar and told the name along

with a novel adjective (e.g., "See this? This is a *blickish* duck!"). After the exemplar was removed from view, the participants were then presented with two test objects. They were asked to give the experimenter the one to which the novel adjective could apply (e.g., "Now, can you give me a duck that is *blickish*?"). The order of the trials was randomized and the children's selection of the test object—whether a property-matching object or a non-property-matching object—was recorded for all trials for later analysis.

**Familiar Adjective Learning Task** The same procedure was administered, only now the adjectives presented were familiar/known and not novel (e.g., "See this? This is a *bumpy* duck!" "Now, can you give me a duck that is *bumpy*?").

**Attention Network Test (ANT)** The ANT trials were administered using E-Prime software on a 15" touch-screen laptop computer. The children sat at a comfortable distance from the screen and used their index finger to touch the fish displayed on the screen. The children were instructed to help feed the hungry (target) fish as fast as they could by touching the mouth of the fish on the screen, according to which direction the hungry fish was oriented. They were told that sometimes the fish would appear alone, and other times it would swim together with other fish. In all cases, they were instructed to concentrate on the one fish in the middle—the hungry fish. They were also asked to keep their eyes on the fixation point during the task. The completion time was approximately 10 min. Their accuracy (percent correct) and reaction times (RTs) were recorded for later analysis.

## Results

All bilingual and monolingual participants came from the same SES background (i.e., middle class) and were matched on vocabulary production through parental reports. Table 1 shows vocabulary size, dominant language, and age.

### Novel Adjective Learning Task

As can be seen in Figure 3, bilingual children performed better than monolingual children,  $t(19)=3.92$ ,  $p<.05$ , in the Novel Adjective Learning Task, selecting property-matching objects with high accuracy, whereas the monolingual children performed at chance.

### Familiar Adjective Learning Task

In terms of overall accuracy on the Familiar Adjective Learning Task, bilingual and monolingual children performed similarly and above chance,  $t(19)=2.75$ ,  $p<.05$ , and  $t(19)=3.18$ ,  $p<.05$ , in selecting property-matching objects (see Figure 3). These results indicate

that the participants were able to comprehend the task at hand and that bilinguals had no special advantage in this task. Thus the advantage observed in the Novel Adjective Learning Task must be due to mapping novel adjectives to the novel properties of known things.

### Attention Network Test

Bilingual children performed better than monolingual children on the ANT,  $t(19)=3.74, p<.05$ , (Figure 4). More critically for the present hypothesis, children’s success in the Novel Adjective Learning Task was significantly correlated with scores from attentional control ( $r=.480, p<.05$ ).

## General Discussion

These results replicate the bilingual advantage in attentional control tasks that has been reported by others and tie this effect to attentional strategies in word learning. The findings promise new insights about the cognitive consequences of learning and speaking two languages and the role of attention in using and learning language. Attention is a process that changes itself through its own activity, a fact that has far-reaching importance for understanding the learning of words and referents by both monolingual and bilingual children.

### The Consequences of Bilingualism

The default assumption in the study of bilingual children has been that their cognitive systems are no different than those of monolingual children, and thus speaking two languages has often been viewed as a source of developmental delays (e.g., Doyle, Champagne, & Segalowitz, 1978). However, we now know there are significant positive consequences that extend beyond language itself and appear to involve executive control processes across many domains—from not taking candy, to sitting still when one should, to—in the present study—shifting attention to novel words and properties of well-known objects. In this way the present study connects the bilingual advantage in executive control to language learning—the context in which that advantage emerged in the first place.

### Attention in Word Learning

By tying the bilingual advantage in executive control to attention shifting in the learning of novel adjectives, the results also suggest that the competitive and attentional processes that are studied in early word learning (in monolinguals as well as bilinguals) may be fundamentally linked to general processes of executive and attentional control. There is a large body of literature in this domain (Diamond, 1990) showing—in monolingual children—incremental advances from late infancy to the school-age years in the ability to switch attention and inhibit prepotent but irrelevant

information. The present results highlight the importance of studying the codevelopment of these processes with word-referent learning in both monolingual and bilingual children. In brief, we may be able to mechanistically ground word-learning strategies in more general attentional processes.

There are certainly intriguing indications that there is still much to be learned from taking this approach. For example, whereas the present task asked children to learn a property label for a known category—and bilingual children showed an advantage—other studies have asked whether bilingual and monolingual children differ in their ability to learn two different names for the same thing. Depending on how one conceptualizes the task, bilingual children either show an advantage at learning two names or exhibit weaker mutual exclusivity constraint in this context (Au & Glusman, 1990; Davidson, Jergovic, Imami, & Theodos, 1997; Davidson & Tell, 2005; Merriman & Kutlesic, 1993). Much of the previous work on this “two names for one thing” task used labels from different languages with different phonological properties. This provides a potentially useful way to understand the microprocesses and context cues that elicit and resolve competitions within and across languages.

In sum, the present work supports the importance of attention in word learning and its link to general processes of attentional switching and executive control. Systematic comparisons of monolingual and bilingual children in both word learning and attentional control tasks offer a new window on these fundamental processes, their development, and their relation to word learning.

Table 1: Productive vocabulary of dominant language based on the MCD.

group	age	noun	verb	adjective	Total
monolingual	36.7	177.9	81.6	48.5	308.0
bilingual	38.9	178.6	83.7	45.9	308.2

### Figures

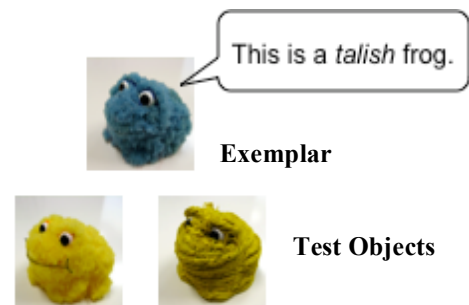


Figure 1: A set of stimulus objects used in the Novel Adjective Learning Task.

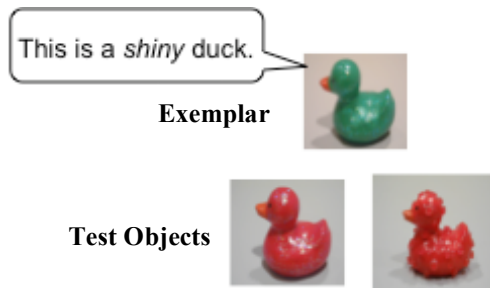


Figure 2: A set of stimulus objects used in the Familiar Adjective Learning Task.

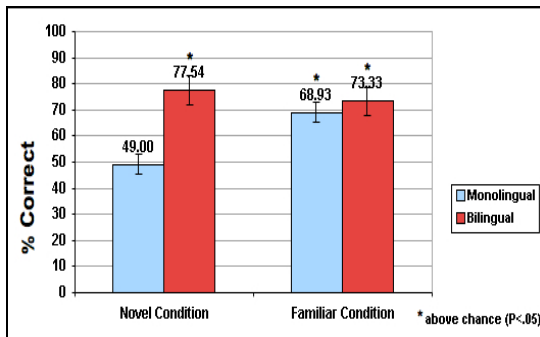


Figure 3: Monolingual and bilingual children's percent correct on mapping novel labels to novel properties (left) and familiar labels to familiar properties (right) in adjective learning tasks.

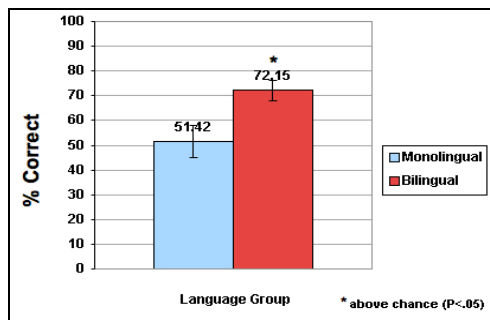


Figure 4: Monolingual and bilingual children's percent correct on the Attention Network Test.

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