

Bilingualism's Influence on Cognitive Ability *

Bradford LEE*¹

*¹ Organization for Fundamental Education

The present research into bilingualism focuses on the aspect of executive control (EC) and how it can relate to cognitive ability. Specifically, bilingual individuals face EC challenges such as mental-set shifting tasks, conflicting-response suppression, and information or task monitoring processes continually while producing or interpreting language. Current research seems to indicate that this constant stimulus gives bilingual individuals a slight advantage in EC processes compared to their monolinguals peers; developing earlier and performing at a higher rate as the subject advance in later life.

Key Words : Bilingualism, Executive Control

1. Introduction

Throughout the years, the attitudes and preconceptions regarding bilingualism have been subject to dramatic changes. This is not surprising, as language to a large degree ties in directly with a person's or group's image of self. Sharing a common language automatically gains one a kind of membership into a group of peers. Conversely, speaking a foreign language from others can serve to ostracize or otherwise set one apart from the group, sometimes in a positive way but most often to the detriment of the speaker. Our sensitivity to language is so acute that different dialects of the *same* language, even different accents or different jargon from those around us can be enough to trigger strong emotions of discontinuity amongst our peers. The concept of Linguicism, or a kind of racism based on language, so named by Tove Skutnabb-Kangas (1989, pp.455) sums up this phenomenon as discrimination based solely on a person's language.

The effects of Linguicism can take either positive or negative forms. For instance, in many communities in America, there is an influx of low-income, lower-educated immigrants who speak a foreign language. The stigma regarding the lower social status of these immigrants lends for a negative Linguicism towards their native languages, adding to a phenomenon of "subtractive" bilingualism. The language of the community is valued more highly than the L1 of the bilinguals, resulting in a general lower ability of the immigrant children in their L1 in favor of the L2. In other cases, such as in Japan, English is a highly admired language, and individuals highly proficient in both Japanese and English are regarded with awe and respect. This forms the basis for "additive" bilingualism, where proficiency and performance of both languages are highly encouraged and nurtured.

2. Problems with Early Research

Due to the prospect of Linguicism affecting the results of any research into Bilingualism, it is extremely important

* 原稿受付 2015年02月26日

*¹ 基盤教育機構

E-mail:bradford-lee@fukui-ut.ac.jp

to have strict checks and balances to assure methodological neutrality. This is perhaps the most difficult hurdle in Bilingual research. Early studies were plagued with methodological inconsistencies which made their results untenable. One early study conducted by Saer in 1923 was conducted during a cultural atmosphere of linguistic and psychological aversion to bilingualism. The study served to add to this stigma by using the results of the Stanford Binet Test for IQ to determine that bilingual Welsh and English teenagers were inferior to English monolinguals and suffered from “mental confusion” (Saer, 1928, pp.38). However, upon closer examination of this study, we find that the test was conducted in English, the weaker second language (L2) of the bilingual children, which may have prevented them from scoring to their full potentials. Other factors, such as the students' economic and educational backgrounds were also not considered, resulting in a lopsided body of participants. It is for these and other reasons that studies prior to the 1960's are largely discredited as faulty and biased.

Keeping these difficulties in mind, researchers are now faced with the enormous task of conducting studies that are methodologically sound. Cultural factors can also have an impact on research results, as different cultures have different norms in relation to their expressions, which is often used as a benchmark for measuring intelligence. For instance, one recent study by Pika, Nicoladis, and Marentette (Pika et.al, 2006, pp.324) found evidence that French-English or English-Spanish bilinguals used more iconic hand gestures when producing speech than their English monolingual counterparts. As both French and Spanish are considered high-frequency gesture languages compared to the relatively low-frequency gesture English, it was concluded that this was the result of language transfer. The gestures “transferred” along with the language so that even when speaking English, more gestures were observed compared to the English monolingual group. Researchers at the University of Alberta sought to follow up on this notion by examining if this phenomenon had any relation to the bilinguals' working memory (Smithson, et.al, 2011). It was hypothesized that apart from being simply an aspect of language transfer, gesture usage may itself be a technique utilized by bilinguals to help alleviate the cognitive load placed on the speakers' working memories while creating speech; indicating a kind of difficulty while producing language. Unfortunately, their results seemed to indicate that cultural standards were the most important determining factor when coming to gesture usage, as bilingual groups were observed to have varying usages depending on the languages involved, and at the same rates when interviewed only in English as compared to the English monolinguals. This result makes the theory of impeded cognitive function amongst bilinguals inconclusive, and most likely erroneous.

3. Facets of Cognition and Executive Control

When speaking of Cognitive Ability, it is first imperative to discuss exactly what form of cognitive facilities are being tested. One aspect of cognitive function often tested by language researchers is that of domain-general executive control (EC) processes. A study performed by Miyake, et.al (Miyake, et.al, 2000, pp.88) found evidence that mental-set shifting tasks, conflicting-response suppression, and information or task monitoring processes, all considered to be under the umbrella of EC, are distinct functions that operate separately from each other. Of specific interest to researchers is then task-switching, a process that is obviously vital to bilingual individuals. A bilingual individual can switch between languages with extreme efficiency, both while creating discourse and while interpreting incoming speech (information monitoring). Not only is performance in each language fluent, it is also free of interference by the other language (conflicting-response suppression), unless in the case of code switching, whereby the speaker intermixes languages

voluntarily (mental shifting). This fact lead researchers to postulate that this constant usage demand would result in an increased proficiency over monolinguals, who have no such requirements.

Bialystock et al. conducted two experiments in an attempt to research this hypothesis. The first (Bialystock et al., 2004) made use of the Simon Task; a test developed to measure response times to a visual stimulus. Participants had to respond to a colored marker by pressing a key on either the left or right side of the keyboard, depending on what color the marker is, regardless of where the marker appears. The colored marker can appear anywhere on the screen, and to add another layer of difficulty, either squares or directional arrows were used as markers. The most challenging situations are when the square marker for "left" appears on the right hand of the screen, and vice versa, or when the arrow marker points in the opposite direction of the correct key stroke. The subject must overcome the reaction to press the key on the same side or direction as the marker and instead consciously apply the rule to respond according to color only. This employs the EC functions of monitoring and switching. Reaction times and number of errors were recorded for the group, of which approximately half were fluent bilinguals. This study sought to control for age, sex, education and social class between bilingual and monolingual groups.

The second study similarly tested EC functions of bilinguals and monolinguals by testing reaction times to a test based on saccadic eye movement (Bialystock et al., 2004). Saccadic eye movement describes the tendency humans have to look towards a flashing object, or in the direction another human is gazing. The experiment added another layer of difficulty to the task by also adding a color cue as in the Simon Task. The test was designed similarly, with participants required to press a key on either the right or left side of the keyboard. The difference with this test was the number of cues. The color marker was the eyes of a picture that would display on the screen that would appear to be gazing to one side or the other. Once the color was displayed, a second flashing cue was shown on one side of the screen. Based on the color of the color marker, the subject had to either press the key on the same side as the flashing cue, or just the opposite. In this scenario, the most difficult pattern was thought to be one where the eyes were gazing towards the flashing cue, but where the color marker dictated the subject must press the key on the opposite side. Another challenge of this experiment had the subject attempt to overcome their natural reflexes and consciously move their eyes to look towards (saccade) or away (anti-saccade) from the flashing marker depending on the color marker.

The results from these experiments were quite clear. For the lower difficulty tasks, both groups recorded quite similar results at the younger age groups. However, on the tasks that were rated as being the most complex, the bilingual groups in both the Simon Test experiment and the saccadic eye movement experiment performed significantly faster than the monolingual groups. This result alone would seem to imply some sort of EC advantage afforded to bilinguals. However a third follow-up study was performed (Bialystok, 2007) that added the extra evidence of magneto-encephalography (MEG) images of subjects' brains while performing the Simon Test. What this study found is that although the reaction times were comparable between bilingual and monolingual groups on tasks of lower difficulty, the action behind the scenes occurring in the subjects' brain were quite different and distinct. While both sets of subjects showed activity in the left frontal structures of the brain, the monolingual groups used regions that are thought to be related to problem solving during the Simon Test, in contrast with the bilingual individuals who showed activity in the regions related to language. This is highly significant because it suggests that bilingual individuals' constant usage of EC functions for language monitoring and task switching fundamentally alters the inner workings of their brains to allow this

ability to be used in other attention tasks. Even nonverbal tasks that are not related to language can be processed in these areas, the so-called Broca's area or BA45.

Another significant finding of Bialystok's Simon Test and anti-saccade studies was the differing performance rates between the bilingual and monolingual paired groups depending on age groups. As would be expected, older subjects showed gradual lags in their response time to the task, compared with younger members of their respective groups. However, when the two groups were compared based on age, they found that degree of this time lag was significantly less for the bilingual subjects (Bialystok et al., 2004, pp.297, Bialystok et al., 2006, pp.1351). While younger age groups showed comparable performances between groups, older bilingual subjects clocked response times considerably faster than their monolingual counterparts. These findings seem to suggest that bilingual individuals are afforded some degree of protection from the gradual declines in EC processes that occur naturally with age.

4. Executive Control Development in Children

Several studies have seemed to indicate that these EC processes also develop earlier in bilingual children. One comprehensive study made use of three nonverbal tasks to examine the cognitive flexibility of bilingual children in the face of conflicting rules (Bialystok, 1999). The various tests sought to examine the children's performance on visually-cued recall tasks, moving word tasks, and the dimensional change card sort tasks developed by Zelazo and Frye (1996). The card sort task makes use of cards with either of two shapes, in either of two colors. The children are first told to sort the cards into boxes depending on one of the criteria, i.e. shapes. Once this has been completed then a new set of rules is introduced whereby the cards must be sorted dependent on the other criteria, i.e. color. The final stage involves the assessor instructing the children to change the rules midway through the activity several times. The difficulty is, children must first learn the rules of the activity, and then ignore them and learn a new set of rules. The final stage can be likened to code-switching among bilingual speakers. It has been shown that preschool age children find it quite difficult to "forget" a set of rules in favor of a new set once they've been mastered. The results of this study showed that bilingual children of ages four to five were more developed in their cognitive complexity, and were better able to perform on the tasks which required ignoring conflicting information.

Other researchers have also taken it upon themselves to try to measure cognitive flexibility in children. Karmiloff-Smith developed a method whereby children were asked to draw nonexistent variations of items that they knew well and could already draw with ease, in an attempt to assess their notation competence and representational change. For example, the assessor would instruct the children to draw, "an X we have never seen before" (Karmiloff-Smith, 1999, pp.61). As children develop, their abilities to think creatively not only advance, but so does their graphic production skills from a procedural as well as a representative standpoint. In this study, the children created several changes to the items while maintaining the basic principle of the item in question, such as altering the size, shape, or location of some elements. Of more interest were the changes that involved the deletion of some elements, or the insertion of heretofore nonexistent elements.

Following this line of research, similar tasks were prepared for bilingual and monolingual groups of children to determine if there was any differences between the two (Adi-Japha, et al., 2010). For this study, the children were

controlled for receptive vocabulary knowledge based on the Peabody Picture Vocabulary Test-III, and also for their ability to infer meaning from pictures using the Illinois Test of Psycholinguistic Abilities. This baseline having been established, the students were then told to draw various imaginary objects and the researchers recorded the number and categories of the variations produced. The results were that the two groups exhibited fundamentally different types of variations in their drawings. Monolingual children made substantially more changes that had an element of deletion, whereas the bilingual children had significantly more insertions. Not only was the bilingual group's rate of insertion higher, it was of a cross-category variety; for example human elements drawn into a plant. This result is most likely related to the theory that bilingual children have an advantage in the comprehension of figures or objects that have inter-representational cues (Bialystock et al, 2005, pp.598). The results of that study by Bialystock et al, showed that bilingual children were more able to identify the dual meanings in ambiguous images, while this study provides evidence that they are more capable of producing them as well.

5. Discussion

Based on the results of the studies introduced here, it would appear that bilingual individuals do benefit somewhat from the constant demands placed on their EC processing center. Not only do these processes seem to develop earlier than in monolinguals as children, but they continue to be more active later in life whereby conflict resolutions tasks are able to be performed faster than monolinguals. Interestingly, it appears that simply being bilingual is not what affords this benefit. A study conducted using bimodal bilinguals, or those who are bilingual in spoken language and sign language, compared performance to monolinguals in EC tasks and recorded no difference between groups (Emmorey et.al, 2008, pp.1202). While sign language is widely recognized as a language with its own syntax, lexicon and phonology, the researchers determined that bimodal bilinguals differ from unimodal bilinguals in that they do not code-switch. Instead, bimodals tend to utilize code-blending, where they are able to simultaneously produce both languages. This effectively eliminates the need for the EC processes of conflicting-response suppression or mental shifting, therefore the "training" of the brain is no greater than a monolingual speaker.

While it may be that bilinguals have an advantage in the cognitive abilities of EC processes, this is not to say that they are more "intelligent". Intelligence comprises a wide range of abilities from logic, abstract thought, comprehension, planning abilities, self-awareness, amongst many others. While impossible to measure definitively, researchers have attempted to compare bilingual and monolingual children's global and nonverbal intelligence and have returned comparable results based on the Wechsler intelligence scale (Sampath, 2005, pp.2049). In fact, one factor that many agree to be critical to determining intelligence, working memory, has not shown to be affected by bilingualism to any measurable degree. When groups of bilinguals were paired with monolinguals of like WM, both groups performed comparably on the Simon Test (Namazi et.al, 2010, pp.605), with no bilingual benefit being apparent.

Clearly, the definitive answer of whether bilingualism has any impact on the cognitive ability of brain has yet to be determined. Bilingualism and language itself has yet to be fully understood to the point where scientists are able to map an individual's progress or proficiency in either their first or second language. In fact, the area that was once commonly believed to play the main role in language production, Broca's area itself has been the subject of several studies with the

benefit of modern imaging technology. The preserved brains of Broca's original two patients, Leborgne and Lelong, were recently put through a battery of tests in an attempt to draw a more concise picture of the damage actually present (Dronkers, et.al, 2007). What was discovered, was that the damage that Broca had originally observed was only a fraction of the actual damage that existed. In addition, the damage to Lelong's brain was located in only the very posterior portion of what is now known as Broca's area. It is now known that this area can also play a role in EC processes, especially amongst bilingual individuals who have more conflict-resolution needs while producing or interpreting speech than monolinguals. As our understanding of the brain and its inner workings increases, we may be more able to visualize what processes are involved in language, and therefore be better equipped to address how this relates to global intelligence.

References

1. Bialystok, E. (1999). *Cognitive Complexity and Attentional Control in the Bilingual Mind*. Child Development. Vol. 70:3, pp. 636-644.
2. Bialystok, E., Craik, F., Klein, R., & Viswanathan, M. (2004). *Bilingualism, Aging, and Cognitive Control: Evidence from the Simon Task*. Psychology and Aging. Vol. 19, pp. 290-303.
3. Bialystok, E., & Shapero, D. (2005). *Ambiguous Benefits: the Effect of Bilingualism on Reversing Ambiguous Figures*. Developmental Science, Vol. 8:6, pp. 595-604.
4. Bialystok, E., Craik, F.I.M. & Ryan, J. (2006). *Executive Control in a Modified Anti-Saccade Task: Effects of Aging and Bilingualism*. Journal of Experimental Psychology: Learning, Memory, and Cognition. Vol. 32, pp. 1341-1354.
5. Bialystok, E. (2007). *Cognitive Effects of Bilingualism: How Linguistic Experience Leads to Cognitive Change*. International Journal of Bilingual Education and Bilingualism. Vol.10:3, pp.210-223.
6. Dronkers, N., Plaisant, O., Iba-Zizen, M. & Cabanis, A. (2007). *Paul Broca's Historic Cases: High Resolution MR Imaging of the Brains of Leborgne and Lelong*. Brain, Vol. 130:5, pp. 1432-1441.
7. Emmorey, K., Luk, G., Pyers, J., Bialystok, E. (2008). *The Source of Enhanced Cognitive Control in Bilinguals*. Psychological Science. Vol.19:12, pp.1201-1206.
8. Karmiloff-Smith, A. (1990). *Constraints on Representational Change: Evidence from Children's Drawing*. Cognition, Vol. 34, pp. 57-83.
9. Miyake, A., Friedman, N., Emerson, M., Witzki, A., Howerter, A. & Wager, T. (2000). *The Unity and Diversity of Executive Functions and their Contributions to Complex "Frontal Lobe" Tasks: A Latent Variable Analysis*. Cognitive Psychology, Vol.41, pp. 49-100.
10. Munoz, D., Broughton, J., Goldring, J. & Armstrong, I. (1998). *Age-related Performance of Human Subjects on Saccadic Eye Movement Tasks*. Experimental Brain Research, Vol. 121, pp. 391-400.
11. Namazi, M., & Thordardottir, E. (2010). *A Working Memory, not Bilingual Advantage, in Controlled Attention*. International Journal of Bilingual Education and Bilingualism, Vol. 13:5, pp. 597-616.
12. Pika, Simone; Nicoladis, Elena, Marentette, Paula (2006). *A Cross-Cultural Study on the Use of Gestures: Evidence for Linguistic Transfer?* Bilingualism: Language and Cognition, Vol. 9, 3, pp.319-327.
13. Smithson, Lisa; Nicoladis, Elena; Marentette, Paula. (2011). *Bilingual Children's Gesture Use*. Gesture, John

Benjamins Publishing Company. Vol.11, pp.330-347.

14. Saer, D.J. (1923). *The Effects of Bilingualism on Intelligence*. British Journal of Psychology, Vol.14, pp.25-38.
15. Sampath, K., (2005). *Effect of Bilingualism on Intelligence*. Proceedings of the 4th International Symposium on Bilingualism, ed. James Cohen, Kara T. McAlister, Kellie Rolstad, and Jeff MacSwan, pp. 2048-2056. Somerville, MA: Cascadilla Press.
16. Skutnabb-Kangas, Tove, and Phillipson, Robert. (1989). "'Mother Tongue': The Theoretical and Sociopolitical Construction of a Concept." In Ammon, Ulrich (ed.)(1989). *Status and Function of Languages and Language Varieties*. Berlin, New York: Walter de Gruyter & Co.
17. Zelazo, P., & Frye, D. (1996). *An Age-Related Dissociation Between Knowing Rules and Using Them*. Cognitive Development, Vol. 11, pp. 37-63. Berlin, New York: Walter de Gruyter & Co.

(平成 27 年 3 月 31 日受理)