Neurocognitive effects of bilingualism

7th class « Linguistics & Neurosciences »
(29/11/2011)
Last week
Language and cognitive control

-PFC: executive functions
(metacognition, cognitive control)
- Regulating thought, action & emotion
  - Inhibition inappropriate thoughts, distractions, actions, and feelings

-ACC: error detection & conflict monitoring
- Receives information about stimulus, selects an appropriate response, monitors the action, and adapts behaviour

-caudate nucleus: control of motor and cognitive activity
Effect on cognition?

-detrimental to child’s cognitive abilities (Darcy, 1963)
  - Semilingualism

-now: focus on potential benefits
  - "the negative results of these studies as being associated with linguistic minorities, where the minority language was being replaced in some sense by the socially dominant one, while the studies that found a positive effect were associated with 'additive bilingualism,' a situation in which majority-language children acquire a second language." (Cummins, 1979)
LA in bilinguals

- early bilingual language exposure optimal for dual language development (Kovelmann & Petitto, 2002);
- simultaneous bilinguals from birth; linguistic milestones in each language achieved at same time (Holowka et al., 2002);
- L2 learners (age 2-9): morphological and syntactic fundamentals acquired within 1st year of exposure (Kovelmann & Petitto, 2003);
- stage-like development L2 learners (age 2-9) comparable to monolinguals (Kovelmann & Petitto, 2003);
- no negative effect of L2 on L1 (Petitto et al., 2003)
What are the benefits?

- Metalinguistic awareness (Bialystok, 1988)
  - Ability to consciously reflect about language
  - Boosted in bilingual development
  - Same referent, different words
  - Cognitive flexibility
Flexible Learning of Multiple Speech Structures in Bilingual Infants

Ágnes Melinda Kovács* and Jacques Mehler

Children acquire their native language according to a well-defined time frame. Surprisingly, although children raised in bilingual environments have to learn roughly twice as much about language as their monolingual peers, the speed of acquisition is comparable in monolinguals and bilinguals. Here, we show that preverbal 12-month-old bilingual infants have become more flexible at learning speech structures than monolinguals. When given the opportunity to simultaneously learn two different regularities, bilingual infants learned both, whereas monolinguals learned only one of them. Hence, bilinguals may acquire two languages in the time in which monolinguals acquire one because they quickly become more flexible learners.
A Familiarization

Speech item

Test

New AAB

New ABA

New speech item

C First look

Overall accuracy

Fig. 1. (A) Familiarization phase of experiment 1. Infants listened to trisyllabic speech items where either the first two syllables were identical (i.e., an AAB structure, as in “lo-lo-vu”) or the first and last syllables were identical (i.e., an ABA structure, as in “lo-vu-lo”). Speech items were followed by a toy appearing in one of two white squares that were displayed continuously on the screen. The location of the toy was predicted by the item’s structure (e.g., left square for AAB, and right square for ABA). (B) Test phase of experiment 1. Infants were presented with new AAB and ABA items, but no toy followed the speech items. We used an eye-tracker to measure where the infants expected the toy to appear. On the right, two scan paths of an infant are depicted on two trials. (C) Measures of learning for the two structures or the two voice cues. Left: Difference scores for first looks [(number of correct looks – number of incorrect looks) / (number of correct looks + number of incorrect looks)] related to the chance level of 0 for ABA and AAB structures (experiment 1: bilinguals, N = 22; monolinguals, N = 22); and for male and female voices (experiment 2: monolinguals, N = 20). Right: Difference scores for overall accuracy for bilinguals and monolinguals in experiment 1 and for monolinguals in experiment 2. Error bars represent SE.
Card sorting task


PAPER

Attention and inhibition in bilingual children: evidence from the dimensional change card sort task

Ellen Bialystok and Michelle M. Martin

Department of Psychology, York University, Toronto, Canada

Abstract

In a previous study, a bilingual advantage for preschool children in solving the dimensional change card sort task was attributed to superiority in inhibition of attention (Bialystok, 1999). However, the task includes difficult representational demands to encode and interpret the task stimuli, and bilinguals may also have profited from superior representational abilities. This possibility is examined in three studies. In Study 1, bilinguals outperformed monolinguals on versions of the problem containing moderate representational demands but not on a more demanding condition. Studies 2 and 3 demonstrated that bilingual children were more skilled than monolinguals when the target dimensions were perceptual features of the stimulus and that the two groups were equivalent when the target dimensions were semantic features. The conclusions are that bilinguals have better inhibitory control for ignoring perceptual information than monolinguals do but are not more skilled in representation, confirming the results of the original study. The results also identify the ability to ignore an obsolete display feature as the critical difficulty in solving this task.
Wisconsin card sorting task

- measure of executive functioning
  - Reported sensitivity to frontal lobe dysfunction

- significant activation of dorsolateral and ventrolateral prefrontal cortex and caudate nucleus (Berman et al., 1995; Cabeza & Nyberg, 2000)
Effect of bilingualism on cognitive control in the Simon task: evidence from MEG

Ellen Bialystok, a,* Fergus I.M. Craik, b Cheryl Grady, b Wilkin Chau, b Ryouhei Ishii, c Atsuko Gunji, d and Christo Pantel e

aDepartment of Psychology, York University, Toronto, ON, Canada
bRotman Research Institute, Toronto, ON, Canada
cOsaka University Graduate School of Medicine
National Institute for Physiological Sciences
Institute for Biomagnetism and Biosignals

Received 8 December 2003; revised 13 November 2004; Available online 13 November 2004

The present study used magnetoencephalography (MEG) to determine the neural correlates of the bilingual advantage previously reported for behavioral measures in conflict tasks. Bilingual Cantonese–English, bilingual French–English, and monolingual English speakers, performed the Simon task in the MEG. Reaction times were faster for congruent than for incongruent trials, and the Cantonese group was faster than the other two groups, which did not differ from each other. Analyses of the MEG data using synthetic aperture magnetometry (SAM) and partial least squares (PLS) showed that the same pattern of activity, involving signal changes in left and medial prefrontal areas, characterized all three groups. Correlations between activated regions and reaction times, however, showed that the two bilingual groups demonstrated faster reaction times with greater activity in superior and middle temporal, cingulate, and superior and inferior frontal regions, largely in the left hemisphere. The monolinguals demonstrated faster reaction times with activation in middle frontal regions. The interpretation is that the management of two language systems led to systematic changes in frontal executive functions.

Keywords: Bilingualism; Simon task; MEG

© 2004 Elsevier Inc. All rights reserved.
Simon task performance

-L2 learners

Table 1
Mean reaction time and accuracy for each condition by group

<table>
<thead>
<tr>
<th>Group</th>
<th>Control</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RT (SD)</td>
<td>%Accuracy</td>
<td>RT (SD)</td>
<td>%Accuracy</td>
<td>RT (SD)</td>
<td>%Accuracy</td>
</tr>
<tr>
<td>Monolingual (N = 10)</td>
<td>425 (76)</td>
<td>97</td>
<td>479 (99)</td>
<td>96</td>
<td>499 (94)</td>
<td>93</td>
</tr>
<tr>
<td>French (N = 10)</td>
<td>415 (64)</td>
<td>98</td>
<td>457 (77)</td>
<td>97</td>
<td>475 (80)</td>
<td>96</td>
</tr>
<tr>
<td>Cantonese (N = 9)</td>
<td>348 (46)</td>
<td>95</td>
<td>378 (65)</td>
<td>93</td>
<td>397 (62)</td>
<td>91</td>
</tr>
</tbody>
</table>
Bridging language and attention: Brain basis of the impact of bilingualism on cognitive control

G. Garbin a, A. Sanjuan a, C. Forn a, J.C. Bustamante a, A. Rodriguez-Pujadas a, V. Belloch b, M. Hernandez c, A. Costa c, d, C. Ávila a, *

a Department of Psychology, Universitat Jaume I, Castelló de la Plana, Spain
b Department of Radiology, FRESA, Valencia, Spain
c Department of Technology, Universitat Pompeu Fabra, Barcelona, Spain
d Institució Catalana de Recerca i Estudis Avançats (ICREA), Barcelona, Spain

ARTICLE INFO

Article history:
Received 11 January 2010
Revised 31 March 2010
Accepted 26 May 2010
Available online 15 June 2010

ABSTRACT

Using two languages on an everyday basis appears to have a positive effect on general-purpose executive control in bilinguals. However, the neural correlates of this effect remain poorly understood. To investigate the brain bases of the bilingual advantage in executive control, we tested 21 Spanish monolinguals and 19 Spanish-Catalan early bilinguals in a non-verbal task-switching paradigm. As expected based on previous experiments on non-verbal task switching, we found activation in the right inferior frontal cortex and the anterior cingulate of monolingual participants. While bilingual participants showed a reduced switching cost, they activated the left inferior frontal cortex and the left striatum, a pattern of activation consistent with networks thought to underlie language control. Overall, these results support the hypothesis that bilinguals' early training in switching back and forth between their languages leads to the recruitment of brain regions involved in language control when performing non-linguistic cognitive tasks.

© 2010 Elsevier Inc. All rights reserved.
Fig. 1. Stimuli and task Conditions. Switching and Non-switch conditions: a “switch” event was defined as the condition of changing the set to be used in order to answer the upcoming stimulus in relation to the previous one (shape-color or color-shape trials). Coherently, a “non-switch” event was assumed to happen when the subject answered the upcoming stimulus with the same set as the previous one (shape-shape or color-color).
General idea

Bilinguals compensate for potential disadvantages in lexical access (delay in picture naming & tip-of-the-tongue states) by improved executive functioning skills.
Deficit in lexical access

Distribution of PPVT Scores

- Monolingual (n=772)
- Bilingual (n=988)

Neurocognitive effects of bilingualism
29-11-2011  Pag.16
Improved executive functioning

Simon Task

Bilinguals faster on congruent and incongruent trials
A different view...

REPORT

What did Simon say? Revisiting the bilingual advantage

J. Bruce Morton and Sarah N. Harper

Department of Psychology, University of Western Ontario, Canada

Abstract

Bilingual children often outperform monolingual children in tasks of cognitive control. This advantage may be a consequence of the fact that bilinguals have more practice controlling attention due to an ongoing need to manage two languages. However, existing evidence is limited because possible differences in ethnicity and socioeconomic status have not been properly controlled. To address this issue, we administered the Simon task to bilingual and monolingual children of identical ethnic and socioeconomic backgrounds. Bilingual and monolingual children performed identically, whereas children from higher SES families were advantaged relative to children from lower SES families. Controlling differences in SES and ethnicity may attenuate the bilingual advantage in cognitive control.
A different view...

On the bilingual advantage in conflict processing: Now you see it, now you don’t

Albert Costa\textsuperscript{a,c,*}, Mireia Hernández\textsuperscript{b}, Jordi Costa-Faidella\textsuperscript{b}, Núria Sebastián-Gallés\textsuperscript{c}

\textsuperscript{a} ICREA
\textsuperscript{b} Departament de Psicologia Bàsica, Universitat de Barcelona, Spain
\textsuperscript{c} Departament de Tecnologies de la Informació i les Comunicacions, Universitat Pompeu Fabra, Spain

\textbf{A B S T R A C T}

We report two experiments exploring more in detail the bilingual advantage in conflict resolution tasks. In particular, we focus on the origin of the bilingual advantage on overall reaction times in the flanker task. Bilingual and monolingual participants were asked to perform a flanker task under different task versions. In Experiment 1, we used two low-monitoring versions where most of the trials were of just one type (either congruent or incongruent). In Experiment 2, we used two high-monitoring versions where congruent and incongruent trials were more evenly distributed. An effect of bilingualism in overall reaction times was only present in the high-monitoring condition. These results reveal that when the task at hand recruits a good deal of monitoring resources, bilinguals outperform monolinguals. This observation suggests that bilingualism may affect the monitoring processes involved in executive control.
To be taken into account

- Longitudinal designs
- Effect of different language educational settings
- Variability in task switching abilities multilinguals (Prior & Gollan, 2011)