The Bilingual Switching Advantage Investigated Using Visual Search

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Introduction

Compared to monolinguals, bilinguals may perform better on tasks that require attentional guidance and conflict resolution arising from distracting information (e.g., Bialystok, Craik, & Ryan, 2006; Hilchey & Klein, 2011). Bilinguals have shown advantages on tasks that recruit executive functions, such as task switching (e.g., Prior & Gollan, 2011; Prior & MacWhinney, 2009). This advantage stems from the continuous selection and suppression required for processing two languages. Bilinguals must resolve the conflict arising from competing languages which leads to advantages in their ability to attend to task relevant information and ignore distracting information (Hilchey & Klein, 2011).

- Successful visual search requires two things: 1) placing attention in the right place, and 2) correctly matching the online visual input with the mental representation of the target held in visual working memory (VWM) (e.g., Hout & Goldinger 2014).
- Ratiu, Hout, Azuma, and Goldinger (2013) investigated the bilingual advantage using a visual search task and found that both bilinguals and monolinguals showed equally efficient attentional guidance, but bilinguals showed a marginal advantage in the amount of time necessary to make perceptual decisions.
- Based on our previous finding, we further examined the bilingual advantage in decision-making using a task-switching paradigm. If bilinguals are better at making decisions, then they should show faster decision times relative to monolinguals. Further, this advantage should be greater when participants are required to rapidly switch between decision types.

Method

Participants

The participants were recruited from Arizona State University undergraduate courses and received partial course credit for their participation. No participants reported a history of neurological impairments.

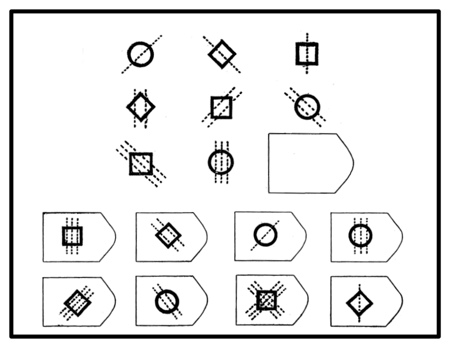
Monolingual (Total *N*=60; Eye-tracking *N*=19). All reported English as their native language and spoke no other languages fluently.

Bilingual (Total *N*=58; Eye-tracking *N*=18). All reported speaking English and another language fluently. Language experience was assessed using a modified version of the Language Experience and Proficiency Questionnaire (LEAP-Q) (Marian et al., 2007).

Stimuli and Procedure

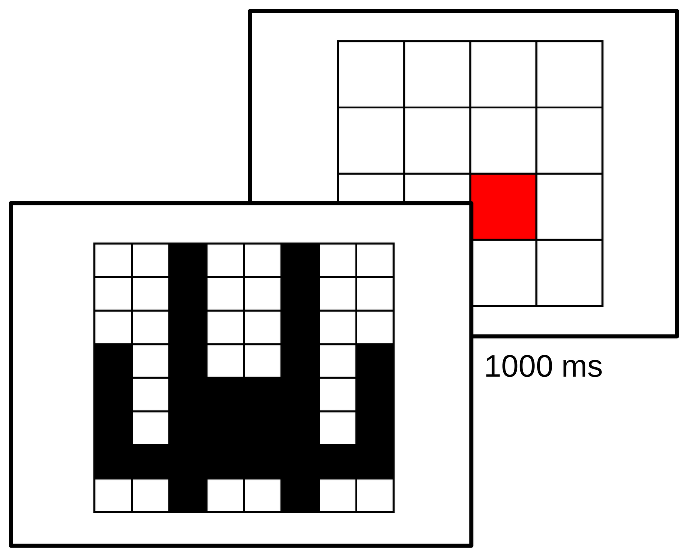
All participants were administered the following tasks: Visual Search Switching Task, Symmetry Span Task (Unsworth et al., 2005), and Raven's Advanced Progressive Matrices (Raven, Court, & Raven, 1986).

Raven's Advanced Progressive Matrices*



Which piece completes the pattern?

Symmetry Span Task*

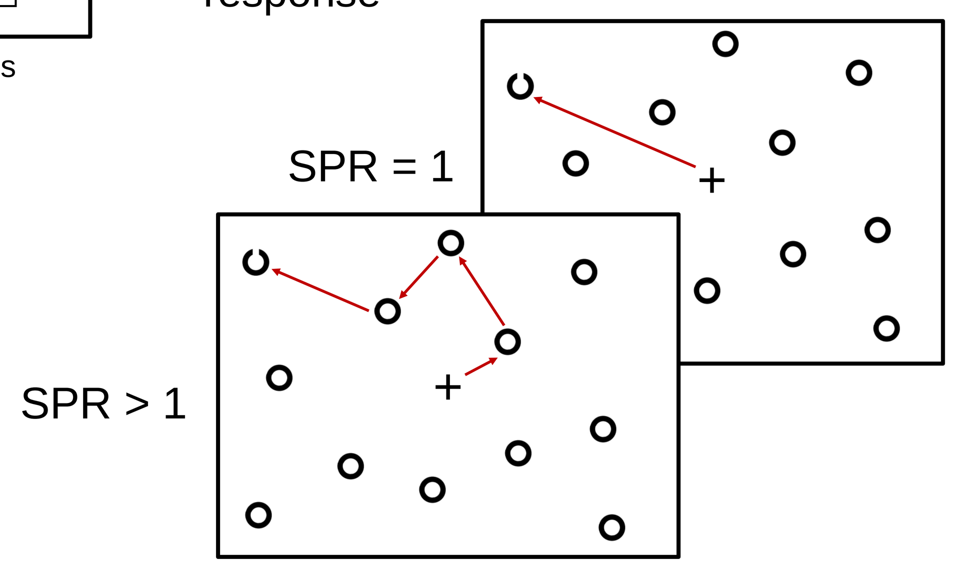


Symmetrical? **YES** or **NO**
Remember the location of the square

Search RTs separated into two time periods:

Scan Path Ratio – summed length of saccades, divided by shortest distance directly to target

Decision-Time – first fixation to manual response

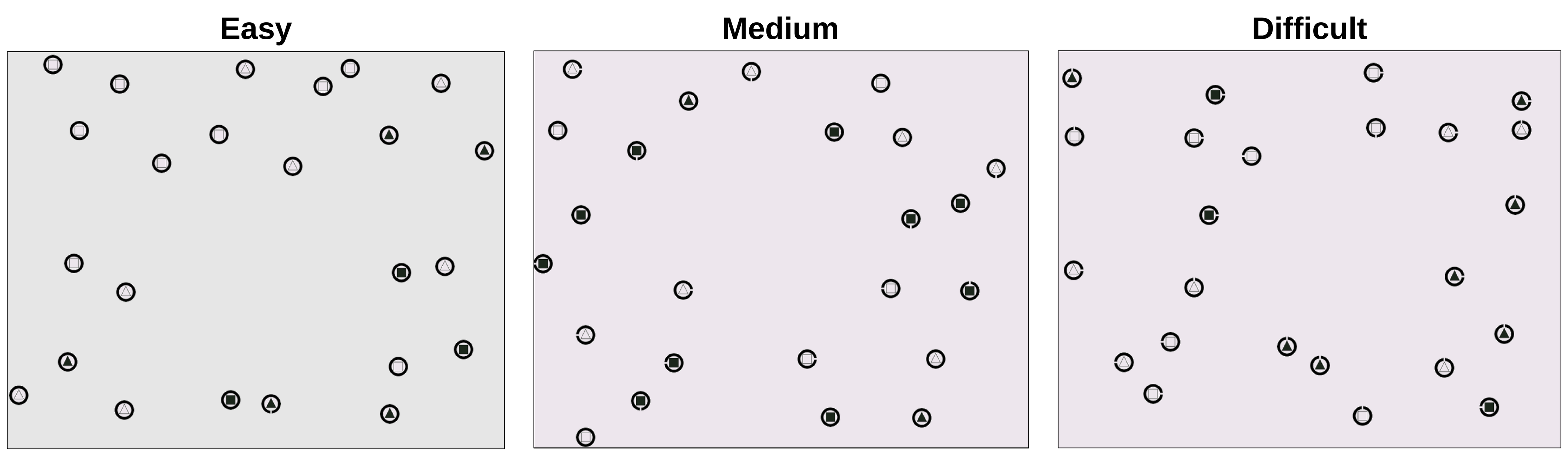


Visual Search Task

search for	*search for*	*search for*
SHAPE	**COLOR**	**SHAPE/ COLOR**

Switching Costs = Switching Trials within Switch Block – Non-Switch Trials in Switch Block

Mixing Costs = Non-Switch Trials in Switch Block – Non-Switch Trials in other blocks



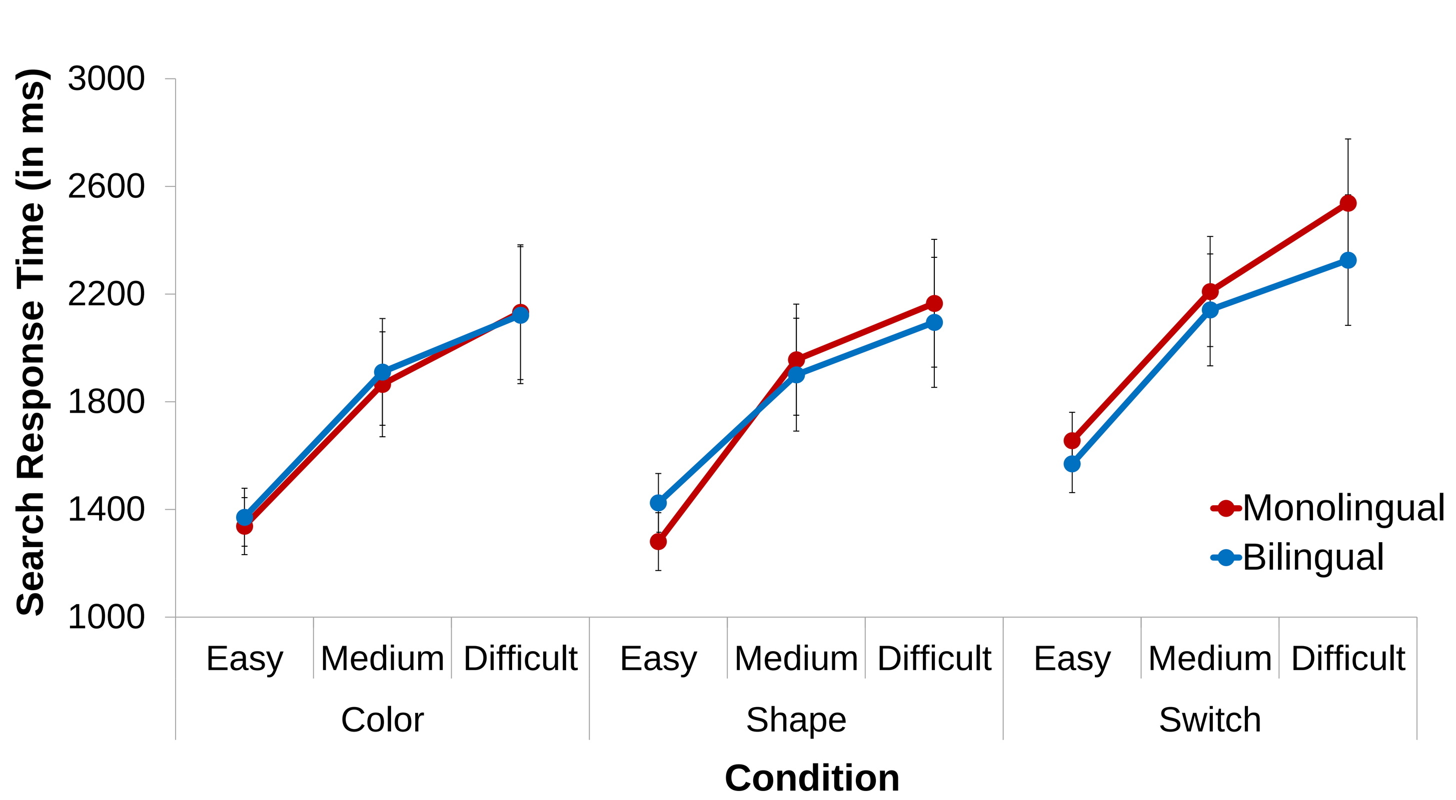
0% orientation distractors | 25% orientation distractors | 100% orientation distractors

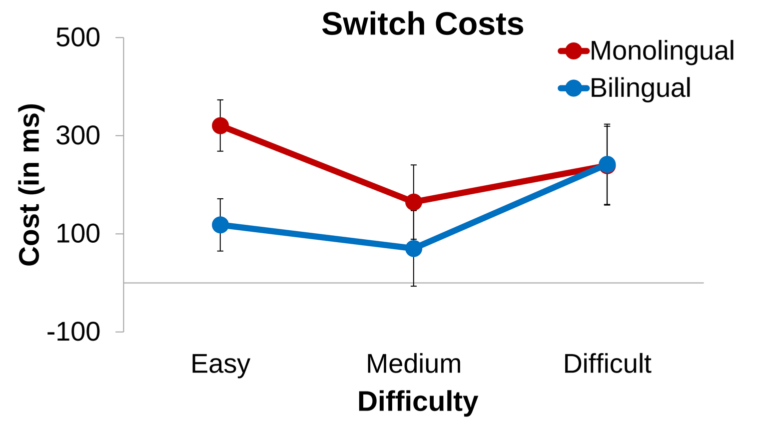
*There were no significant group differences between bilinguals and monolinguals for Raven's Advanced Progressive Matrices or the Symmetry Span Task (both *t*'s <1).

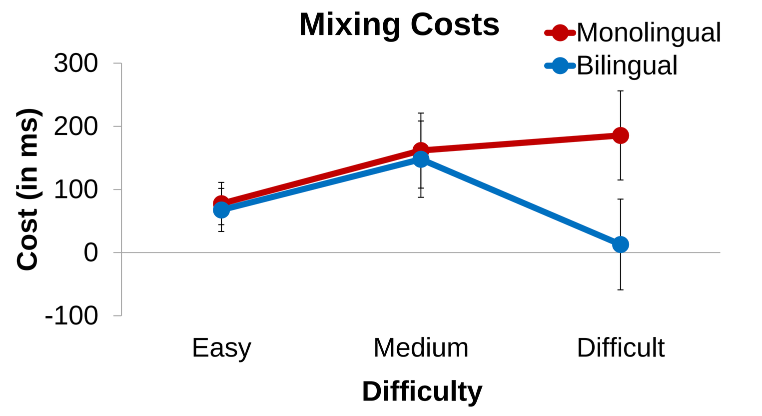
Results

Data were analyzed in a 2 (Language Group) X 3 (Condition: Color, Shape, Switch) X 3 (Difficulty: Easy, Medium, Hard) mixed model Analysis of Variance (ANOVA). Switching and mixing costs were analyzed using a 2 (Language Group) X 2 (Cost: Switching, Mixing) X 3 (Difficulty: Easy, Medium, Hard) mixed model ANOVA.

Overall Search Time



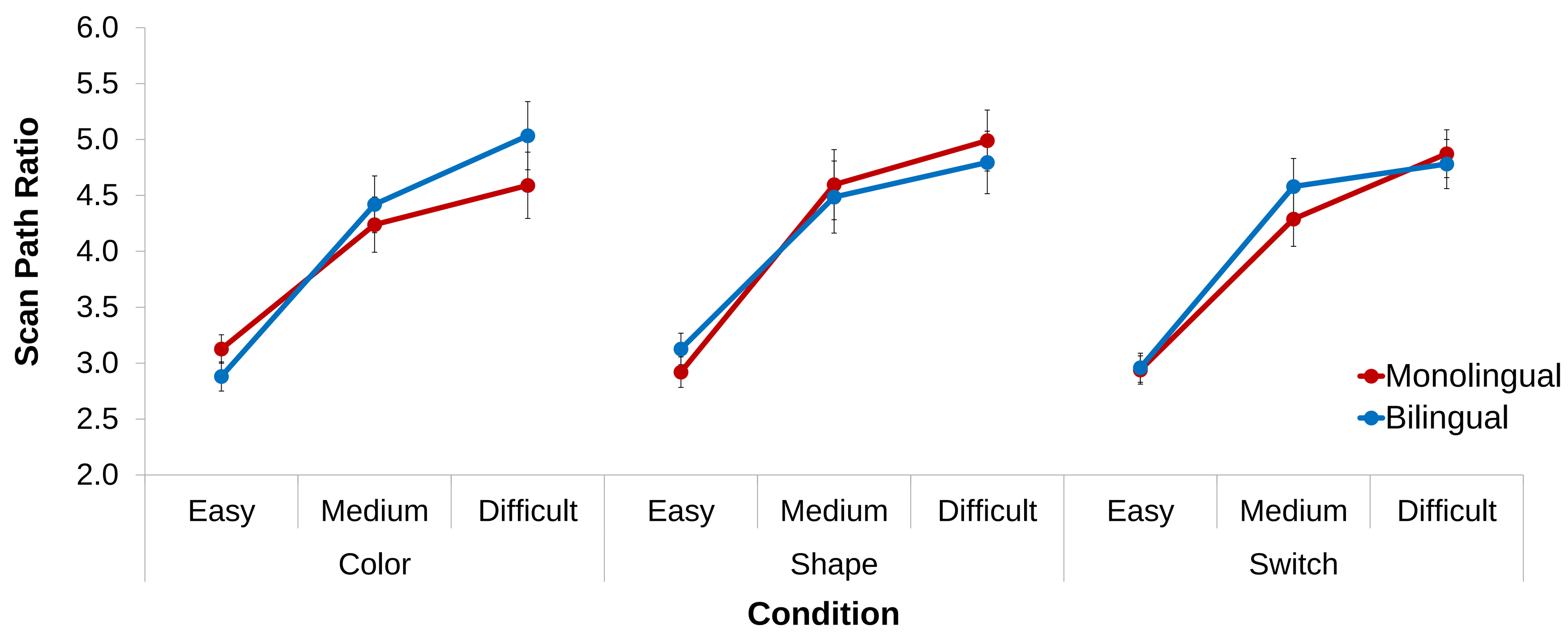




Sig. effect of Condition [$F(2, 232)=45.46$, $p<.001$, $\eta_p^2=.282$]
Sig. effect of Difficulty [$F(2, 232)=50.62$, $p<.001$, $\eta_p^2=.304$]
Marginal Condition X Language Interaction [$F(2, 232)=2.79$, $p=.064$, $\eta_p^2=.023$]

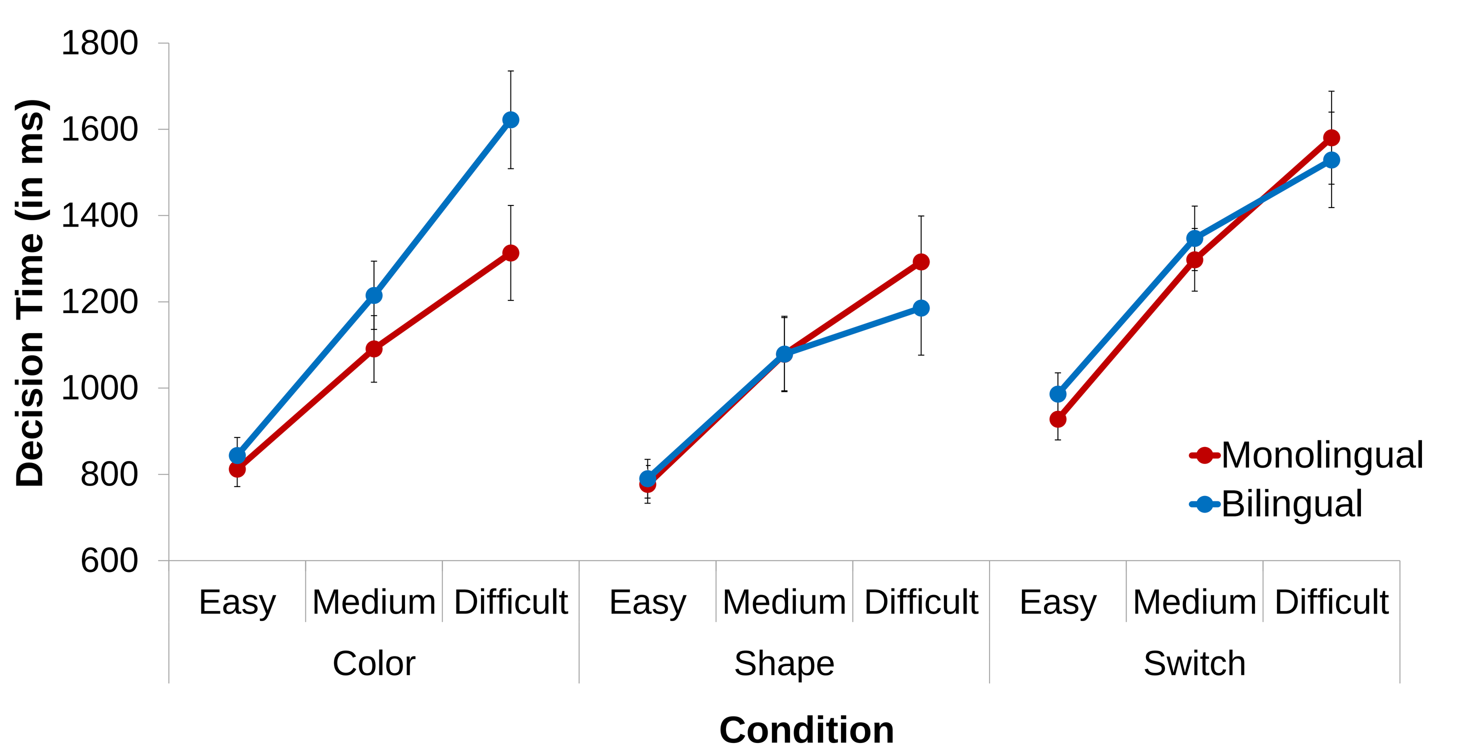
Sig. effect of Language [$F(1, 116)=5.014$, $p=.027$, $\eta_p^2=.041$]
Marginal Cost X Difficulty Interaction [$F(2, 232)=50.62$, $p=.065$, $\eta_p^2=.023$]

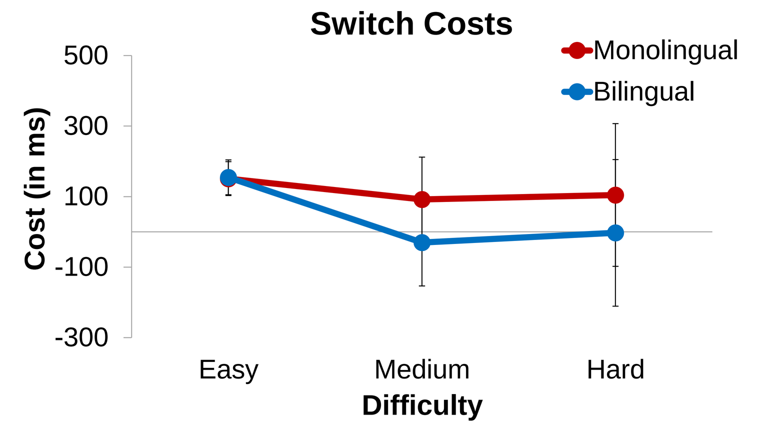
Scanning

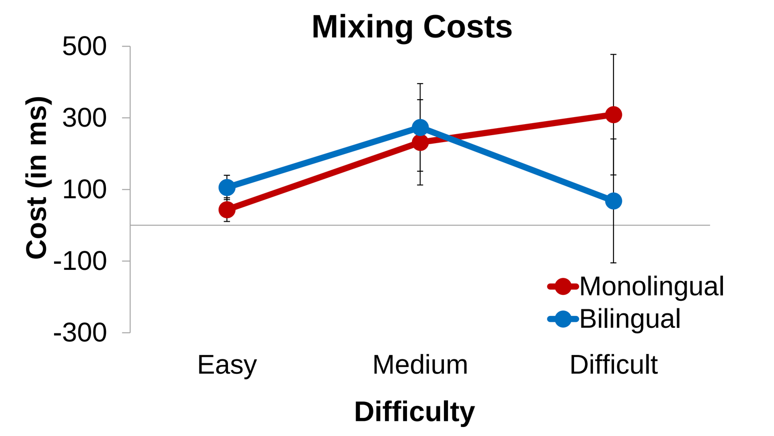


Sig. effect of Difficulty [$F(2, 70)=147.14$, $p<.001$, $\eta_p^2=.808$]

Decision Time







Sig. effect of Condition [$F(2, 70)=16.24$, $p<.001$, $\eta_p^2=.318$]
Sig. effect of Difficulty [$F(2, 70)=79.70$, $p<.001$, $\eta_p^2=.695$]

Discussion

- Similar to our previous study, there were no bilingual advantages in attentional guidance, as measured by scan path ratios.
- We did not find a bilingual advantage in decision times, but there was a trend showing that bilinguals had reduced mixing costs for decision times under the most difficult search conditions.
- Interestingly, a bilingual advantage was observed in the overall search times. Bilinguals showed overall reduced switching and mixing costs compared with monolinguals, a result consistent with other studies (e.g., Prior & Gollan, 2011; Prior & MacWhinney, 2009).
- The present results suggest that both bilinguals and monolinguals have equally efficient attentional guidance, but bilinguals may have an advantage in matching a target item to information held in VWM.

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