Cognitive control in bilingual aphasia

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Introduction

The ability to suppress irrelevant information requires cognitive control. This process plays a key role when bilinguals are required to speak one language and inhibit the non-target language. Previous research evaluating linguistic and non-linguistic inhibition in bilingual and monolingual healthy adults has revealed a bilingual advantage on non-linguistic tasks (Bialystok, 2001; Costa et al., 2008; Luk et al., 2010). However, a case study comparing healthy bilinguals, monolinguals, and bilingual aphasic patients contradicts the aforementioned studies (Green et al., 2010), suggesting that linguistic cognitive tasks may require different processing demands than non-linguistic cognitive tasks. No study has yet systematically examined cognitive control in bilingual aphasia to determine whether deficits in language inhibition are specific to the language domain or are a more general cognitive deficit. The current study investigates the degree to which language general cognitive control in bilingual aphasia is based in the cognitive domain or language domain. We predict that the language inhibition deficits noted in bilingual patients is language domain specific rather than cognitive domain general.

Methods

Twenty-eight Spanish-English neurologically healthy bilingual adults (NHBA) (mean age = 49) and 8 Spanish-English bilingual adults with aphasia (BAA) (mean age = 54) participated in this study. Data collection is on-going; we anticipate a total of 30 NHBA and 10 BAA. Participants are either English or Spanish dominant and either simultaneous or sequential language learners with first language (L1) being English or Spanish.

All NHBA and BAA completed non-linguistic and linguistic tasks requiring inhibition of irrelevant information. The non-linguistic task was based on Erickson and Erickson's (1974) Flanker Task and included congruent and incongruent conditions. The linguistic task consisted of word pairs that varied by language direction from prime to target (English-Spanish, Spanish-English, and within-language pairs) and 5 stimulus types: translation (Tr), e.g., ant-hormiga "ant"; semantic-related non-translation (S), e.g., ant-spider; semantic-related with translation (STr), e.g., ant-araña "spider"; unrelated non-translation (Un), e.g., ant-church; and unrelated translation (UnTr), e.g., ant-iglesia "church".

All tasks were delivered on E-Prime (Psychology Software Tools, Inc.). The timing was 350 for patients and 250 for controls. Participants were given adequate time to press the button. Accuracy and reaction time was calculated.

Results

All controls ($t(26) = -6.671$, $p < .001$) and patients ($t(7) = -2.381$, $p < .05$) show faster reaction times for the congruent than the incongruent tasks on the flanker task.

We performed logistic regressions separately for each group (NHBA and BAA) to evaluate the effect of condition on accuracy. Results show that NHBA (x^2 (4, $N = 28$) = 63.978, $p < .001$) and BAA (x^2 (4, $N = 8$) = 82.58, $p < .001$) are more accurate on related words pairs (e.g., ant-spider) compared to unrelated conditions (e.g., ant-church). This indicates an advantage for processing words that are semantically related compared to words that are not semantically related.

We then conducted a one-way ANOVA for NHBA to evaluate the effect of condition on RT. Results show that NHBA have faster response times RT on translation (e.g., ant-hormiga), semantic (e.g., spider-ant), and semantic translation (e.g., spider-hormiga "ant") conditions compared to unrelated conditions (e.g., spider-church or spider-iglesia "church") ($F(4, 270) = 9.933$, $p < .001$). *Post hoc* LSD pairwise comparisons showed that Tr is the fastest condition compared to S which is faster than STr (**$p < .001$**) (see Figure 1).

To evaluate BAA RT data, we first computed z-scores from raw RT data because the RT data showed great variability across patients. With z-scores, we conducted a one-way ANOVA for BAA to evaluate the effect of condition on RT. Results indicate that BAA do not show significant RT effects between stimulus types (p = .226). This suggests that BAA do not show effects of suppressing irrelevant linguistic information or do not benefit from semantic facilitation effects. Upon visual inspection of individual patient data, we found different patterns. Two of the eight patients showed faster RTs for the Tr condition, suggesting that they benefit from this type of word processing compared to S and STr; however, five patients showed faster RTs for STr condition relative to the S or Tr conditions, suggesting that these patients benefit more from semantically related words that they translate compared to words that are semantically related or direct translations (see Figure 2).

Conclusions

Results show that even though controls and patients are both capable of showing the congruency effect on the Flanker task, bilingual patients with aphasia do not efficiently process cross-language semantically related information. this data suggests that controls are consistently faster on semantically related conditions compared to unrelated condition and between the related conditions, Tr is the fastest. Patient data do not show this trend. Notably, the STr condition for controls is faster than Un and UnTr conditions but slower than S or Tr indicating that combining semantic and translation added a cost to the processing. STr requires two processes: making a semantic association and changing languages and this is still faster than Un and UnTr. The data shows that there is a tradeoff in making two steps. Individually, S and Tr are faster but when they are combined (STr), it takes longer. Some patients are fastest on the Tr condition; however, most patients are fastest on the STr condition. This suggests that inhibition deficits in patients are found in the language domain and are dissociable from the general cognitive domain because both patients and controls show congruency effect on the Flanker task.

In sum, our results show that patients demonstrate the ability to complete a non-linguistic task requiring general cognitive domain processing but are not able to perform the linguistic task that requires cognitive processing. These results suggest that there is a dissociable aspect of general cognitive processing in cognitive domain versus the language domain.

References

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Figure 1

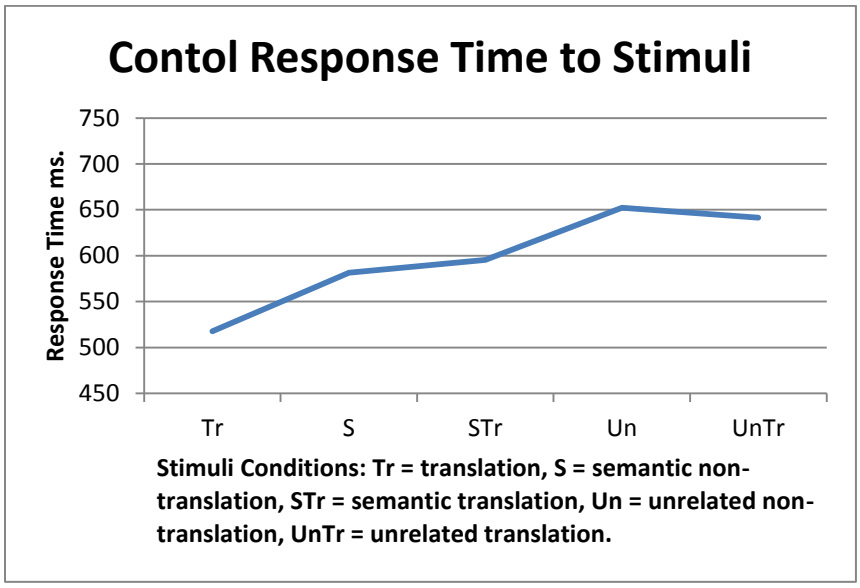
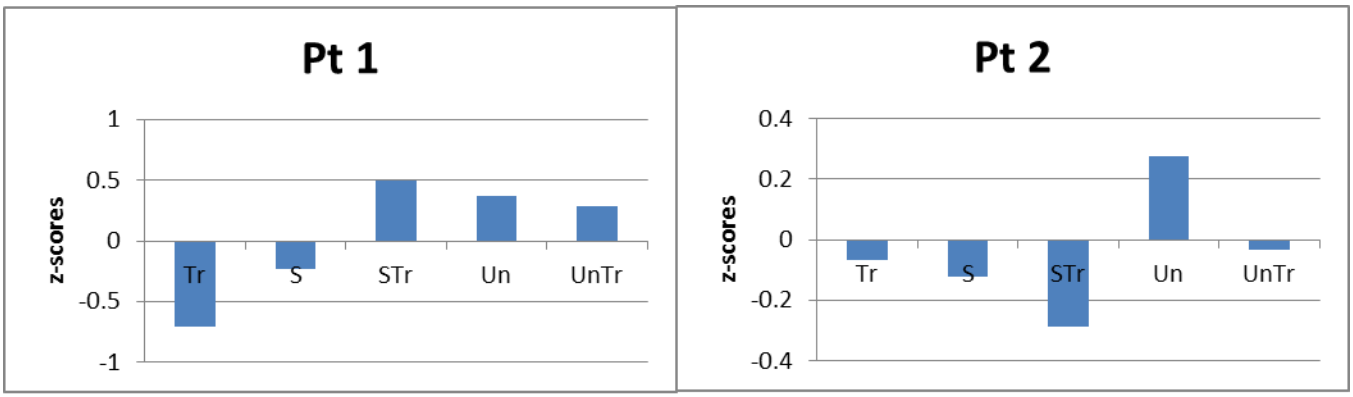


Figure 2:



Stimuli Conditions: Tr = translation, S = semantic non-translation, STr = semantic translation, Un = unrelated non-translation, UnTr = unrelated translation