The consequences of native language regulation for bilingualism and second language learning

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More than a decade ago, on the 125th anniversary of the journal *Science*, Kennedy and Norman (2005) identified the biological basis of second language (L2) learning as one of the top 125 questions to be answered in the next 25 years of research in all of science:

Research articles published on **Second Language Acquisition** and **Bilingualism** since 1985 (*Web of Science*)
There has been a virtual explosion of research on bilingualism:

Figure 1. Results of search for topic “bilingualism” on Thompson-Reuters Web of Science for (a) number of papers published and (b) number of citations of those papers for years 1993 to 2012. (From Kroll & Bialystok, 2013, *Journal of Cognitive Psychology*)
What have we learned in the recent upsurge of research?

- Recent neuroscience evidence has called into question the presence of hard constraints on L2 learning; proficiency in L2 may often be more important than age of acquisition (e.g., Abutalebi et al., 2005; Steinhauer et al., 2009) and the brain may outpace behavior in revealing L2 learning. **There is far greater plasticity than previously understood.**

- But there are consequences: **proficient bilinguals may not be monolingual-like in their native language**, suggesting that the native language is open to change and to the influence of the L2 (e.g., Ameel et al., 2009). **Competition across the two languages may reshape the networks that support each language.**
The idea that I examine in this talk is that the regulation of the native or dominant language may be critical for both proficient bilingual performance and for new adult L2 learning. It may also be related to some phenomena that have been identified as attrition.

- The native language may be suppressed to enable fluent L2 use.

- Successful L2 learners may be individuals who are able to tolerate change to the native language. That change may involve processing costs that initially slow the native language and make native language performance more error prone, make learners initially less sensitive to some features of the native language, and that open the native language to the influences of the L2.

- The regulation of the native language may be at least partly responsible for some of the advantages reported to be associated with bilingualism, including new language learning.
A question of great interest is whether and how the evidence for native language regulation is related to language attrition:

Are changes to the L1 a natural consequence of second language learning and bilingualism that reflect a more dynamic and plastic language system than previously understood?

Are some changes to the L1 enduring and others not?
Three discoveries provide a framework for thinking about bilingualism

1. Both languages are always active and competing.  
   *The two languages are not separate*

2. The native language changes in response to learning and using an L2.  
   *Bilingualism has consequences for both languages*

3. The consequences of bilingualism are not limited to language but reflect a reorganization of brain networks that hold implications for the ways in which bilinguals negotiate cognitive competition more generally.  
   *Bilingualism has consequences for the mind and the brain*

A word on terminology:

_Bilinguals and Second Language (L2) Learners_

We adopt a broad definition of bilingualism to include all individuals who use more than one language regularly.

We distinguish bilingual groups with respect to their proficiency in the L2, their relative language dominance, the age of acquisition, and the degree to which the context of language use supports each of the two languages.

We focus on those speakers for whom the native language and the L1 are the same.
How do the mind and brain accommodate the presence of two languages? **The bilingual is a mental juggler**: Both languages are active regardless of the requirement to use one language alone:

How does a bilingual select a given language to be used at any moment?
Three discoveries about bilingualism:

1. Both languages are always active and competing.

2. The native language changes in response to learning and using an L2.

3. The consequences of bilingualism are not limited to language but reflect a reorganization of brain networks that hold implications for the ways in which bilinguals negotiate cognitive competition more generally.

Cross-language interactions are persistent.

At the **lexical** level, we see them even when bilinguals are processing words in sentence context, even when they are not required to use one of the two languages at all, even when the bilinguals are highly proficient in the L2, and even for language pairings that are highly dissimilar (e.g., Hoshino & Kroll, 2008; Morford et al., 2011).

At the level of the **grammar**, we see them when structures in the two languages converge (e.g., Hartsuiker et al., 2004) and when they conflict (e.g., Dussias & Sagarra, 2007).

At the level of the **phonology**, we see them at the earliest stages of L2 learning (e.g., Chang, 2012; Jacobs et al., in press) and when bilinguals are highly proficient.
An illustration of language nonselectivity: The phonology of the language not in use modulates the time for bilinguals to read words in each language.

Cognates with identical/similar orthography but similar or different phonology:

<table>
<thead>
<tr>
<th>English</th>
<th>Spanish</th>
<th>Cross-language phonology</th>
</tr>
</thead>
<tbody>
<tr>
<td>piano</td>
<td>piano</td>
<td>Similar [+p]</td>
</tr>
<tr>
<td>base</td>
<td>base</td>
<td>Different [-p]</td>
</tr>
</tbody>
</table>

Schwartz, Kroll, & Diaz (2007): Bilinguals are faster to name cognates in L2 when the phonology converges from L1 to L2. But the same result for reading in the dominant L1. The cross-language effects are bidirectional.
Deaf signers judge the semantic relatedness of two words in English. The ASL translations of the English words have a “phonological” form relation or not. Deaf signers are faster to judge the English when the ASL converges and slower when it conflicts. Monolingual English speakers do not show these effects.
But sometimes, these cross-language interactions are seen only in the brain data, not in behavior.

Thierry and Wu (2007): Proficient Chinese-English bilinguals access the L1 translation equivalent when performing semantic relatedness judgments in English, their L2.

The critical manipulation in this study was the presence of a repeated character in the Chinese translation of the English words: The bilinguals did not see the Chinese words in the experiment.

| Table 1. Experimental design and stimulus examples |
| Chinese character repetition (implicit factor) | Semantic relatedness (explicit factor) | Semantic relatedness (explicit factor) |
| Repetition (R+) | | |
| Post–Mail | Semantically related (5+) | Semantically unrelated (5–) |
| You Zheng–You Jian | | |
| Huo Che–Huo Tui | | |
| 邮政－邮件 | 火车－火腿 |
| 火车－火车 | | |
| SRC 4.34 (±0.40) | SRC 1.50 (±0.35) | |
| SRC 4.03 (±0.64) | SRC 1.27 (±0.26) | |
| Wife–Husband | Apple–Table |
| Qi Zi–Zhang Fu | Ping Guo–Zhuo Zi |
| 妻子－丈夫 | 苹果－桌子 |
| SRC 4.28 (±0.47) | SRC 1.37 (±0.44) |
| SRC 3.93 (±0.65) | SRC 1.26 (±0.24) |
| No repetition (R−) | | |
| | | |
| | | |
| | | |
The bilinguals were sensitive to the character repetition suggesting that they were accessing the translation equivalent in L1 to perform the semantic task in L2:

But there was no evidence for the activation of the translation in behavior.
Other evidence that the ERP record may be a more sensitive measure of early stages of L2 learning than behavior: McLaughlin et al. (2004)

We need converging measures of language processing to fully understand the course and consequence of cross-language activation.
What is the consequence of parallel activity and competition across the bilingual’s two languages?

Juggling the two languages may tune brain networks that enable control and build cognitive reserve.
The hypothesis is that juggling creates a need to negotiate competition across the two languages so that the use of each language is controlled to enable fluent performance.

Skill in resolving cross-language competition is hypothesized to create expertise that affects not only language but cognition and the brain. Bilinguals become expert jugglers.

The regulation of the native language may be critical. The juggling of the two languages may change cognition but may also change the L1 itself.
Three discoveries about bilingualism:

1. Both languages are always active and competing.

2. The native language changes in response to learning and using an L2.

3. The consequences of bilingualism are not limited to language but reflect a reorganization of brain networks that hold implications for the ways in which bilinguals negotiate cognitive competition more generally.

Being bilingual is not only about acquiring and using the L2 but also about the ways that the native or dominant L1 changes in response to using the L2: the native language may take a hit!

- When learners are immersed in an L2 environment during study abroad or when traveling, the L1 is suppressed (Baus et al., 2013; Linck et al., 2009).
Examined the performance of L2 learners who were all native English speakers at an intermediate level of studying Spanish as the L2.

One group was **studying abroad in Spain and immersed** in the L2 environment whereas the other group was studying in the classroom in very monolingual Pennsylvania.

*L1 activity was reduced in both comprehension and production when learners were immersed in the L2 environment.*
Linck et al. (2009): Semantic verbal fluency in immersed vs. classroom learners: Name as many exemplars of a category as possible in 30 seconds.

The immersed learners had lower semantic fluency in **English**, the L1. Taken together with their performance on a translation recognition task showing that they were insensitive to lexical distractors in the L1, these data suggest that they were suppressing the L1 while living in the L2 context.
A secondary (in preparation) analysis of the time course of production in the verbal fluency task showed that the time to begin to produce the first word in English was slower for immersed learners.

But do they recover from this apparent inhibition as they continue to speak the L1?
No! We see a sustained pattern throughout the 30 second trial in English in which immersed learners produce fewer English tokens than their classroom counterparts. This suggests that the immersion effect is not simply due to an initial inhibitory effect on initial L1 retrieval but persists throughout the retrieval process. They produce more in Spanish but continue to produce less than their classroom counterparts in English.
Native language change during early stages of second language learning
Kinsey Bice and Judith F. Kroll

NeuroReport 2015, 26:966–971

There is L1 change during immersion but what happens in classroom learners? Are there changes that can be observed early in the course of learning a new L2?

We used ERPs in addition to measures of behavior to ask the question of whether the new L2 begins to affect the dominant L1 even at very early stages of L2 learning when immersed in an L1 dominant context.
Bice & Kroll (2015): Native English speaking monolinguals and L2 learners performed a lexical decision task in English while EEG was recorded. In lexical decision they simply decide if a letter string is a real English word but some of the words were cognates with their new L2, Spanish.

**tomato** in English; **tomate** in Spanish

The question was whether the newly acquired Spanish would come to influence performance in English.

- In the EEG data, cognate effects are present in L2 for intermediate learners, starting to emerge for beginning learners, and absent for monolingual speakers of English. *Critically, we see these effects in the brain data but not in behavior. Behaviorally, the learners look like monolinguals.*
Fig. 1

<table>
<thead>
<tr>
<th></th>
<th>Monolinguals</th>
<th>Beginning learners</th>
<th>Intermediate learners</th>
</tr>
</thead>
<tbody>
<tr>
<td>-10 μV</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>10 μV</td>
<td></td>
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</tbody>
</table>

**CZ**

ERPs for English (L1) cognates and noncognates. Top row: ERP waveforms from the representative electrode CZ for cognates (black line) and noncognates (red line) in English. Note that negative is plotted up. Bottom row: ERP scalp topography showing the distribution of the effect from 300 to 400 ms (left) and from 400 to 500 ms (right). Scale is from −2 (blue) to 2 (red) microvolts. Difference wave was calculated by subtracting noncognate amplitude from cognate amplitude; therefore, positivity (red) indicates that cognates have reduced negativity compared with noncognates. ERP, event-related potential.
These results suggest that effects of L2 on L1 are beginning to emerge early in learning and may reflect the dynamics of language change that are required to become a proficient bilingual.

A study underway is examining this process to determine whether individual differences in the ability to change the native language predict success in learning outcomes.

Will these differences correspond to different cognitive consequences? Our hypothesis is that differences in the ability to regulate the L1 may be critical in predicting cognitive outcomes.
The two studies presented focused on L2 learners. But what about proficient bilingual speakers? Some previous studies (e.g., Costa & Santesteban, 2004) have argued that the effects on the L1 are only present for those, like learners, who are highly L1 dominant.
Misra, Guo, Bobb, & Kroll (JML, 2012)

Use ERPs to examine the earliest time course of cross-language activation in bilingual speech planning.

The effect of language blocking in picture naming in the L1 and L2.

Relatively proficient Chinese-English bilinguals but dominant in L1 Chinese.

**Group 1:** Name pictures in L1 then L2  
**Group 2:** Name pictures in L2 then L1

The pictures were the same for both languages; two blocks per language: **L1, L1, L2, L2** or **L2, L2, L1, L1**
Blocked Picture Naming: Early indices of inhibition

Inhibitory pattern for L1 and facilitatory pattern for L2:

If it were a matter of recovering from momentary inhibition following naming in L2, then later in the L1 naming blocks we should see this recovery but the pattern persists, suggesting the presence of global inhibition.

*In this study, there was little evidence for inhibition in the behavioral measure.*
Does behavior also reflect this early inhibitory pattern for the L1?

Moriyasu, Hoshino, & Kroll (in preparation) examined simple picture naming for Japanese-English bilinguals who were highly proficient in English as the L2 and living in the US but still very dominant in L1 Japanese.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Japanese (L1)</th>
<th>English (L2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self rating proficiency (1-7 scale)</td>
<td>6.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Category fluency (in 30 seconds)</td>
<td>48.3</td>
<td>38.6</td>
</tr>
</tbody>
</table>
When L1 is named first, we see the expected pattern of faster naming latencies for L1 than L2.

When L1 is named after L2, they are slower to speak Japanese than English! A **reversal of their normal language dominance.**

Related evidence:

- Van Assche et al. (2013)
- Branzi et al. (2014)
The evidence that bilingualism has consequences for language processing and inhibitory control is now compelling.

But inhibitory control may involve different brain networks that are engaged in specific ways to solve different types of language processing problems. A focus in the recent research has been to examine these effects of bilingualism and language experience on the brain.
Abutalebi & Green (2007): Different loci of cognitive control in the bilingual brain: different components of inhibition?

Fig. 1. Multiple levels of cognitive control and bilingual language production. The figure schematically illustrates the neural devices responsible for cognitive control (see text for details) as displayed on a BrainVoyager template. Cognitive control emerges from the integration of separable neural systems including the anterior cingulated cortex, the basal ganglia, the inferior parietal lobule and most prominently the prefrontal cortex (for illustration’s sake these areas are represented on the same axial brain slice). Each of these systems is responsible for distinct aspects of cognitive control as outlined in the “callout” boxes of the figure. In the domain of language, cognitive control refers to processes not directly concerned with the representation of language (i.e., lexical items), but rather with the selection and temporal sequencing of such representations. During bilingual word production, cognitive control may be at work in order to achieve the correct selection of the lexical item in the target language and to keep it free from non-target language interferences. This is achieved through the normal interplay of the mentioned neural devices: the left basal-ganglia and the anterior cingulate cortex will modulate activity in the left prefrontal cortex providing a normal modulatory influence on the systems mediating word production (left prefrontal cortex and inferior parietal cortex).
Guo, Liu, Misra, & Kroll (2011): fMRI evidence

Distinct patterns of neural activation were found for local inhibition as compared to global inhibition in bilingual word production but it is the native language that is differentially affected.

The dorsal anterior cingulate cortex (ACC) and the supplementary motor area (SMA) appear to play important roles in local inhibition, while the dorsal left frontal gyrus and parietal cortex appear to be important for global inhibition.
These studies of cross-language interaction suggest that not only does the L1 influence the L2, but the L2 has persistent effects on the L1, for both learners and highly proficient bilinguals. Negotiating these influences has been hypothesized to confer some of the observed consequences to cognition in the realm of executive function.

The effects of bilingualism on the L1 are not just about words. We see related phenomena at every level of language processing, including the grammar and phonology. We do not know whether constraints on these dynamics are similar at all levels of language processing.
Three discoveries about bilingualism:

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Bilingualism good for the brain, researchers say

The skill helps improve multitasking and prioritizing, and helps ward off early symptoms of Alzheimer's disease, experts say.

"Being bilingual has certain cognitive benefits and boosts the performance of the brain, especially one of the most important areas known as the executive control system," said York University psychology professor Ellen Bialystok at the annual meeting of the American Association for the Advancement of Science being held in Washington, DC.

Bilingualism Is Like A Mental Gymnasium For The Brain

Juggling languages can build better brains
A brief new language learning experience improves attention for even older learners!
Bilingualism may change the efficiency of the brain networks responsible for resolving competition and conflict in non-linguistic tasks.

What is the neural basis of the bilingual effect in resolving conflict?
Speaking at least two languages may protect against cognitive impairment after stroke, according to a new study published in *Stroke*, a journal of the American Heart Association.

**Being bilingual 'beats strokes': 40% of people who speak multiple languages recover full mental functions compared to 20% who only speak one**

- Edinburgh University study looked at more than 600 stroke victims in Hyderabad
- First time a study has looked at the relationship between the number of languages spoken and a patient's cognitive outcome after stroke
- Switching between languages offers constant 'brain training', which helps you recover

The study "adds to the body of evidence" that bilingualism can result in a better cognitive outcome, "even in an acute brain event like stroke," said lead author Suvama Alladi, DM, who at the time of the study was at Nizam's Institute of Medical Sciences in Hyderabad, India, and is now professor, neurology, National Institute of Mental Health and Neurosciences, Bangalore, India.

Being bilingual is just one way to try to boost brain power; others include playing a musical instrument or doing Sudoku puzzles on a regular basis, Dr Alladi noted.

The study was published online November 19 in *Stroke*.

The analysis included 808 adult participants from the stroke registry at Nizam's Institute of Medical Sciences who had sustained an ischemic stroke and were evaluated within 3 to 24 months.
Debate Rages over Whether Speaking a Second Language Improves Cognition

Some studies show that the purported “bilingual advantage” may be only a myth

A heated debate over this issue now rages in the research community and has gained prominent attention recently with a series of articles in the journal *Cortex*. A paper by Kenneth Paap of San Francisco State University and colleagues kicked off the fireworks in August, arguing that the evidence now suggests either no bilingual advantage exists, or it only occurs under certain as yet undetermined circumstances. Twenty-one commentaries and a summary by Paap and colleagues followed in October.
But there are failures to replicate some previously reported findings.

Paap & Greenberg (2013): No advantage for young adult bilinguals on behavioral measures of executive function.


Morton & Harper (2007): Perhaps it’s a matter of different demographics for comparing bilingual and monolinguals? Not so simple: Bilingualism contributes above and beyond SES.

Costa et al. (2009): Only see an advantage in EF when demands on monitoring are high. Basically, the tasks need to be sufficiently difficult.
Bilingualism has a diverse set of consequences over the lifespan – these are not a simple matter of an advantage or not.

To understand the consequences of bilingualism, we need to understand how bilinguals use language.

The critiques on the consequences of bilingualism have largely reported correlational data on the performance of different language groups on executive function tasks; they have not examined language processes directly.
But not all bilingual experience produces the same consequences.

The use of two languages may impose processing demands that create distinct profiles of bilingual cognition. Different forms of bilingualism may have the consequence of differentially tuning the neural networks that support language use (e.g., Green & Abutalebi, 2013). Some bilinguals code switch frequently and others not at all. Some languages share similar form and others to do not. But in all cases, bilinguals must potentially negotiate a higher level of competition in their everyday use of language than monolinguals.

The ability to acquire these regulatory mechanisms and to use them to effectively control the L1 may be a crucial component of successful L2 learning and may also determine at least some of the observed consequences of bilingualism.
There is a great deal of research on the consequence of bilingualism for executive function. But there is another benefit:

Bilinguals are better language learners than monolinguals.

Why learn a foreign language? Benefits of bilingualism

Learning a foreign language is more than just a boost to your CV or handy for travelling. It will make you smarter, more decisive and even better at English, says Anne Merritt.
<table>
<thead>
<tr>
<th>Study</th>
<th>Monolingual Participants</th>
<th>Bilingual Participants</th>
<th>Language of Instruction</th>
<th>Language to be Learned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Papagno &amp; Vallar (1995)</td>
<td>Italian</td>
<td>Italian-Other</td>
<td>Italian (L1)</td>
<td>Russian</td>
</tr>
<tr>
<td>Van Hell &amp; Candia Mahn (1997)</td>
<td>English</td>
<td>Dutch-English (also French, German)</td>
<td>L1 (Eng/Dutch)</td>
<td>Dutch/Spanish</td>
</tr>
<tr>
<td></td>
<td></td>
<td>English-Mandarin</td>
<td>English (L1)</td>
<td>Artificial</td>
</tr>
</tbody>
</table>

There are bilingual advantages in learning new vocabulary.

In the past studies, learners acquired the new vocabulary via the L1. But L1 may play a special role with respect to processes of self-regulation.
Bogulski, Bice, & Kroll (in preparation):

In the final study I will present, we test the hypothesis that the experience that bilinguals have in regulating the L1 to enable proficient performance in the L2 is responsible for the observed bilingual advantage in word learning.
The question we asked in the present study was whether performance would differ when bilinguals learn new words via their L1 or L2.

If the bilingual advantage in word learning is an effect of the cognitive consequences of bilingualism more generally, then bilinguals may outperform monolinguals regardless of whether they learn new words via the L1 or L2.

If the bilingual advantage in word learning is due to specific experience that bilinguals have in regulating the L1, then learning via the L1 may be more likely to produce benefits than learning via the L2.
Study Task: see the Dutch word and name the English translation

fiets

+ bike

2 seconds

Up to 5 seconds
### Experiment 1: English-Spanish bilinguals vs. monolingual English speakers

<table>
<thead>
<tr>
<th></th>
<th>N for Sessions 1 and 2</th>
<th>N for Session 3</th>
<th>Mean Age</th>
<th>Mean Days Between Sessions 1 and 2</th>
<th>Mean Days Between Sessions 2 and 3</th>
<th>Mean L1 Rating</th>
<th>Mean L2 Rating</th>
<th>Mean O-Span Score (out of 60)</th>
<th>Mean Simon Difference Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>English monolinguals</td>
<td>21</td>
<td>15</td>
<td>20.43 (0.22)</td>
<td>1.90 (0.15)</td>
<td>25.07 (2.00)</td>
<td>9.55 (0.15)</td>
<td>3.80 (0.31)</td>
<td>43.95 (2.01)</td>
<td>33.30 (3.65)</td>
</tr>
<tr>
<td>English-Spanish bilinguals</td>
<td>22</td>
<td>13</td>
<td>23.23 (0.86)</td>
<td>2.00 (0.20)</td>
<td>28.54 (3.73)</td>
<td>9.75 (0.07)</td>
<td>7.96 (0.20)</td>
<td>50.82 (0.88)</td>
<td>27.14 (3.57)</td>
</tr>
</tbody>
</table>

Both groups are learning the new Dutch words via English, the L1.
We find a bilingual advantage but the English-Spanish bilinguals are very slow at study. Maybe they are slow people?
Performance on a picture naming task:

The bilinguals are not slow when they are not attempting to learn new information.
### Experiment 2: Do Spanish-English bilinguals learning via the L2 show the same advantage?

<table>
<thead>
<tr>
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<td>(0.88)</td>
<td>(3.57)</td>
</tr>
<tr>
<td>Spanish-English bilinguals</td>
<td>19</td>
<td>14</td>
<td>26.68</td>
<td>2.00</td>
<td>24.79</td>
<td>9.46</td>
<td>8.96</td>
<td>43.79</td>
<td>43.25</td>
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<td></td>
<td></td>
<td>(1.07)</td>
<td>(0.25)</td>
<td>(2.21)</td>
<td>(0.21)</td>
<td>(0.21)</td>
<td>(1.51)</td>
<td>(5.03)</td>
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</table>

The Spanish-English bilinguals are not as closely matched but are immersed and more proficient in the L2. The bilinguals are learning via English, the L2.
The Spanish-English bilinguals show no bilingual advantage. They are slow at study in their L2 English but not as slow as The English-Spanish bilinguals in their L1!
The Chinese-English bilinguals are fast at study but show no bilingual advantage. In a picture naming task in English, the L2 they are slower than monolinguals but not in learning.
• Only bilinguals learning new words via the L1 reveal a bilingual advantage in word learning.

• Word learning performance is not predicted by cognitive measures alone on memory span or executive function nor by time studied.

• Studies of inhibitory control in language processing suggest that bilinguals have experience in regulating the L1 to enable proficient L2 performance. *Regulation imposes costs to L1 processing but produces later benefits.*
The studies I have presented suggest that L2 learners and bilinguals acquire the ability to regulate the L1.

There is much that we do not know:

To what degree will we observe changes in the L1 grammar and phonology as L2 learning proceeds?

What is the relation between language regulation and cognitive control? How do individual differences modulate this relationship?

What are the dynamics associated with different components of L1 regulation? What is the scope and time course of these different components? There may be global control across the entire language but also local control and these processes may vary whether they are short lived or enduring.

The answers to these questions may be critical to understanding the relation between L1 regulation and L1 attrition.
The bilingual may be a mental juggler but the science of how language experience changes the brain and behavior is only beginning to identify the factors that may be required to provide a comprehensive account of bilingualism and its consequences.

We would know none of this if we studied monolinguals only. The implications are not just for our interest and curiosity – they require a revision of the traditional story about language development and about the plasticity associated with adult learning.

Thank you!