

The HAROLD of predictive processes in sentence comprehension

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Aging brings dramatic changes to human brain in both structural and functional levels. A well-known phenomenon of aging, the Hemispheric Asymmetry Reduction in Older Adults (HAROLD) (Cabeza, 2002), characterizes the reduced activations in the left prefrontal cortex and the increased activations in the right homologue regions for tasks involving working memory, visual attention, and episodic retrieval in elders. Previous studies suggested that neural mechanism underlying sentence comprehension in the inferior frontal gyrus (IFG) for controlled semantic retrieval, the dorsal medial prefrontal cortex (dmPFC) for inference making, and the dorsal lateral prefrontal cortex (dlPFC) for executive function. This study aimed to examine the HAROLD phenomenon by investigating how aging modulate the predictive process of sentence comprehension in the brain. Twenty-seven young adults and 25 healthy elders served as participants in the fMRI study. Eighty leading sentences were subdivided in to high and low predicative (HP vs. LP) condition, based on the cloze probability of the ending word. We presented the leading sentence for 4 seconds and asked participant to read for comprehension and to predict the upcoming ending words. Then, when the target word appeared, they were asked to decide whether the presented endings were the same as their predictions. Both young and elderly groups revealed that the LP sentences showed greater activations in the left fronto-temporal network than the HP sentences did. These findings suggested the increasing demand on the lexical access and semantic integration. For examining the hemisphere differences of predictability effect between groups, we performed the regions of interest (ROIs) on the IFG, dmPFC, and dlPFC. The results showed, comparing to the young adults who showed greater activations in the left IFG and dmPFC than those in the right regions, elders showed no differences in activations between hemispheres in these three ROIs. Together, our findings showed the HAROLD phenomenon and suggested the age-related compensatory mechanism in sentence comprehension.

Granger Causality and Matrix Spectral Factorization with Applications in Neuroscience

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Granger causality [5] is a statistical tool providing a numerical estimation of whether the process generating stationary time series $\{Y_k\}_{k \in \mathbb{Z}}$ causes another process of generating stationary time series $\{X_k\}_{k \in \mathbb{Z}}$.

Expanding these ideas, Geweke [4] has defined a frequency dependent causality for more than two processes involved. Dhamala et al. [1] have shown that computation of such causality is reduced to factorization of power spectral density matrix of a stationary time series, which is known as non-parametric method of Granger causality computation. Since then, Wilson's matrix spectral factorization algorithm [6] has been widely utilized by the neuroscience community in order to estimate functional causalities of different brain area activities, analyzing multichannel EEG recordings. However, if power spectral density matrix is degenerate or ill-conditioned at some isolated frequency points in the domain, then Wilson's algorithm fails to perform an accurate factorization. As it is mentioned in [3], such singular situations are common in the study of unstable biological systems. In the presentation, we would like to demonstrate that the novel matrix spectral factorization algorithm [2] is capable of overcoming above mentioned obstacles. Thus, this algorithm leads to new opportunities for accurate estimation of frequency dependent Granger causality, for complex systems containing unstable modes.

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The Effect of Lifelong Bilingualism on Adulthood Cognitive Control

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The cognitive advantage of bilingualism has been reported in many recent studies (e.g. Bialystok et al., 2005). The frequently reported explanation for the origin of the cognitive advantage is that bilinguals use two languages regularly. Controlling concurrent activations of the two language systems requires inhibiting the unwanted language and activating the language which is contextually relevant. This persistent practice of selecting one language and suppressing another enhances the development of cognitive control which in turn enables bilinguals perform better than monolinguals on non-linguistic tasks (e.g. Bialystok et al., 2006, 2008). Once this cognitive advantage is acquired, bilinguals should consistently use both languages throughout their life to preserve the advantage for the later age (e.g. Craik & Bialystok, 2006a, 2006b). This means, the durability of the bilinguals' cognitive advantage is reliant on the amount of the first and the second languages they use throughout their life. However, previous studies in which this claim has been made have not examined the bilinguals' lifelong language experience; rather they just compared bilinguals to monolinguals.

Examining the association between the amount of the first and the second languages used throughout the bilinguals' life and the degree of adulthood cognitive control is particularly essential since, in reality, bilinguals do not always use both languages 'consistently' throughout their life. Bilingualism is a dynamic process; any change of language environment that the bilinguals experience in their life can affect the magnitude of both languages they use (Bot, 2008). As a result, it was hypothesized, in this study, that if using both first and second languages 'regularly' throughout the bilinguals' life is compulsory for the sustainability of the cognitive advantage, it is likely that the changes in the amount of first and second languages that bilinguals experience at some point in their life can affect the magnitude of their cognitive control during late adulthood. To examine this assumption, three specific questions were addressed: (1) Is there an association between the lifelong balance between first and second languages and cognitive control? (2) Does the amount of first and second languages used at different ages of bilinguals have different magnitude of affect on the degree of bilinguals' cognitive control during adulthood? (3) Does the speed of first and second language processing have an association with cognitive control?

To answer the questions, the lifelong language balance of 20 Frisian/Dutch bilinguals (age, $M = 64$) was examined by determining the amount of the first and second languages they used at 3 age levels (Childhood & Adolescence (< 20), Early & Middle Adulthood (21 - 40) and Mature Adulthood (> 40)). The amount of the two languages they used was assessed using a language history questionnaire which contained three elements: lists of basic questions about events that could affect the magnitude of use of the first and the second languages (e.g., moving home), list of the age of the participants (1-80) and self-rating scale (100% Frisian-100% Dutch). The magnitude of balance between the two languages was determined by computing the absolute difference between the magnitudes of the two languages used (as absolute value \uparrow , the magnitude of balance \downarrow). The bilinguals' speed of languages processing was determined by measuring the speed of lexical retrieval using Picture Naming task (RT was measured using Praat, SUBTLEX-NL to measure word frequency and CELEX to measure word length), and by examining the

number and duration of pauses in the bilinguals' free speech (bilinguals' speech after watching two Charlie Chaplin movies). The Simon task was employed to assess the bilinguals' level of cognitive control. Linear mixed effect models were fit using the lmer function of lme4, R version 3.2.0 to analyze the data. Test-lmer was employed to estimate the p-value.

The study has not confirmed the association between the magnitude of lifelong bilingualism and later age cognitive control that has been claimed in previous studies. Moreover, no association was found between the magnitude of balance at different ages of the bilinguals and the bilinguals' adulthood cognitive control. There was also no effect of the speed of language processing. Three assumptions are forwarded for the absence of these associations. The bilinguals in this study have not used both languages 'consistently' as stated in previous studies; their early age language exposure was dominated by Frisian. Thus, it is likely that due to the lack of equal access to the two languages during childhood, their cognitive advantage did not emerge. It can also be the case that other extraneous variables interplay with the magnitude of balance to determine the cognitive advantage; just the magnitude of balance and a few examined confounding variables (e.g. working memory) may not be able to predict the degree of cognitive control. Finally, the cognitive advantage did not emerge probably due to the similarity between the two languages.

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Multilingual advanced learners of Arabic employ deep parsing during online comprehension: Evidence against Shallow Structure Hypothesis

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The differences in sentence processing between natives and late proficient learners have been extensively debated. The popular Shallow Structure Hypothesis (SSH) (Clahsen & Felser, 2006a, 2006b, 2018) assumes that learners (L2ers) employ two different parsers during online comprehension of complex dependencies: deep for L1 and shallow for L2. That is, L2ers rely heavily on semantic and pragmatic cues instead of structural ones, even if they resembled L1 structures. However, others (Cunnings, 2017a, 2017b; Hopp, 2014; McDonald, 2006) believe that one parser is used for both L1 and L2. That is, the comprehension differences could be ascribed to working memory and other processing issues. Contrastive patterns of (un)ambiguous relative clause attachment (RCA), see (1), during offline/online experiments have been used to test these competing hypotheses. However, many contrasted English to European languages. Moreover, very little work involved the Asian subcontinent or less investigated languages, such as Arabic. Furthermore, context effect on L2ers has been hardly ever studied (Clahsen & Felser, 2018). In this study, we examined the online parsing strategies among Arabic bilinguals from the Hindi Belt comparing their Arabic RCA patterns to that of the Syrian natives (L1ers), providing new insights from typologically distinct languages (Arabic being head-initial & Hindi/Urdu head-final). Investigating this new pair is critical to test/generalize the predictions of SSH.

(1) The killer shot the servant of the actor who was standing on the balcony.

Offline RCA in Arabic among L1ers/L2ers was tested and confirmed in a separate norming study. Both L1ers and L2ers attached high (“the servant” was the dominant answer to “Who was standing on the balcony?”). This was predicted by SSH. Indeed, offline, the L2ers are parsing like natives despite having an opposite RCA: Hindi L1ers attach low (Gryllia, Féry, Kügler, & Pandey, 2015). 24 items adapted from the offline norming study were used to create two identical self-based reading (SPR) experiments to study the online parsing and initial interpretation of RCA among L1ers/L2ers. The experiments contrasted two referential contexts with high and low attachment RCs, a 2X2 design. That is, the preceding context could be either NP1/NP2 biasing (C1/C2) as in (2):

(2) The servant has always been good and loyal. However, the servant’s life ended tragically.

(3) The killer shot the servant(s) of the actor(s) who was/were standing on the balcony.

The temporarily ambiguous RCs got disambiguated numerically as indicated by the RC pronoun, auxiliary, and main VP (our critical regions) forcing either a high/low (N1/N2) attachment interpretation, as in (3). 48 fillers were added to the items then were shown to the participants in four Latin-squared presentation lists in centered non-cumulative SPR tasks using Opensesame (Mathôt, Schreij, & Theeuwes, 2012). Each sentence was followed by a comprehension question to ensure active reading. L1 participants (N=52) were monolingual university students living in Homs, Syria (22 males, mean age: 23, range: 18:32). The L2ers (N=52, all male, M=23, 20:30) were undergraduate and graduate students of Arabic in Delhi. All L2ers came from Islamic school background. Their L1 is Hindi/Urdu. Log reading times (RT) at the critical regions were analyzed using linear mixed models in R (lme4).

Together, the two experiments challenge the SSH assumptions. L1ers, indeed, showed little sensitivity to the context overall; we found marginal effect of context at the relative pronoun ($t=1.7$) and marginal effect of interaction with attachment ($t=1.8$). The Arabic default high attachment was actually too strong, driving the effect as was shown in the nested contrast for N1 attachment ($t=2.1$). This was expected under SSH (Pan, Schimke, & Felser, 2015). This trend continued at the post-critical regions. The L2ers, were initially sensitive to the context ($t= 2.97$), yet this trend did not remain in the post-critical regions. Surprisingly, we constantly found significant main effects which were related to default high attachment ($t= 6.9$), but no effect of context. Results indicate that L2ers are parsing like natives and deploying a deep parser despite their initial susceptibility to the referential context effects which are predicted by Cunnings (2017b) who links interference to inefficient retrieval of memory cues.

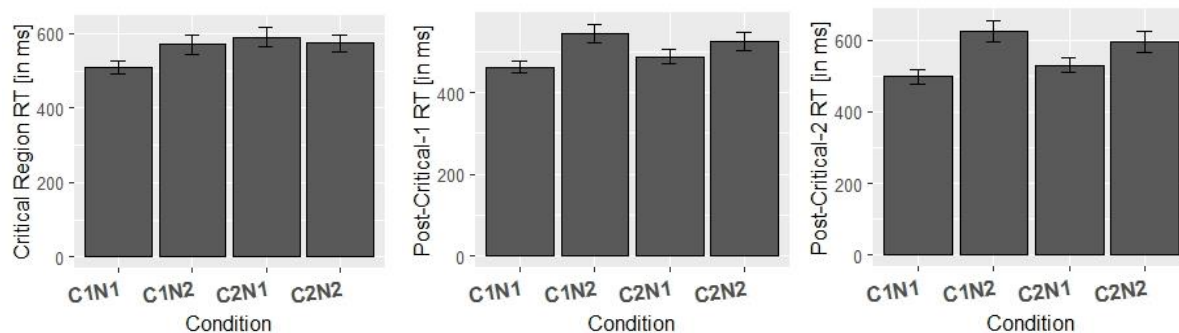
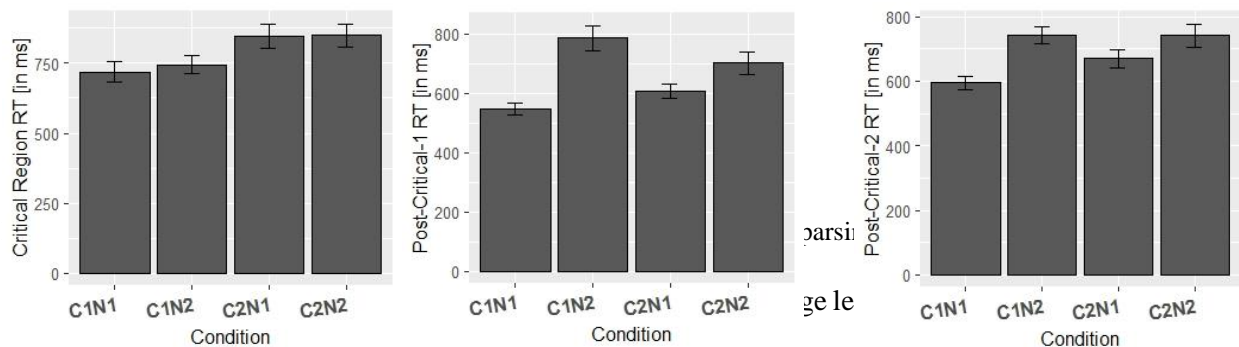


Figure (1): Average L1ers RTs at the critical regions shows their default RCA (C1N1&C2N1) driving the effect



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The role of language use in lexical processing in English-French and French-English bilinguals

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This study focuses on one of the foremost questions surrounding bilingual lexical access: whether the languages of the bilingual are accessed separately (language selective access) or together (language non-selective access). A review of the extant psycholinguistics literature exhibits a temporal dichotomy: the majority of older research in the field supports a selective access and separate lexicon account, whereas the more contemporary literature collectively indicates non-selective access of shared lexicons. A possible confound with many of these recent studies, however, was addressed by Thierry and Wu (e.g. 2004, 2007) when they highlighted that the use of mixed language stimuli in the design could encourage dual-language processing in bilinguals. Accordingly, the experiment reported here attempts to test the findings in the contemporary literature with a more robust methodology which uses single language stimuli in order to ensure that any potential activation of the bilingual's other language is not due to the multi-language nature of the task. A group of 185 French-English and English- French bilinguals of varying proficiencies took part in a fully French online masked lexical decision task which made use of stimuli pairs with a hidden morpheme repetition when the critical prime-target pairs were both translated into English. For example, a critical prime-target pair could be 'noir-chantage' (black-blackmail) or 'courrier-chantage' (mail-blackmail). The inclusion of native French speaking bilinguals (alongside the native English bilinguals) with a wide range of language proficiencies addresses a further aim of this research; to investigate whether it is possible to observe any behavioural L1-L2 facilitatory effects. To date, there has been very little evidence for fast, automatic L1-L2 translation in unbalanced non-simultaneous bilinguals, with most studies instead focusing on L2-L1 translation as the influence of language dominance means that the latter effect would most likely be far stronger than the former. A series of mixed effects linear regressions were performed on the cleaned data set, with participants and stimuli items as random factors, morphemes and controls as item-level factors, and a host of demographic characteristics as individual-level factors. Results showed a significant main effect of hidden morpheme repetition in only the native English speakers, with no facilitation effect at all for the native French speakers. Additionally, there was a significant interaction between subjects' language use and the condition prime across the whole cohort of subjects. These findings are discussed with respect to the predictions of three prominent models of bilingual lexical access (the RHM, the BIA/BIA+, Multilink).

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Assessing Audio-Visual Integration in Speech in Minimally Verbal Young Children with Autism Spectrum Disorder

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Poor integration of speech sounds with the mouth movements likely contributes to language acquisition deficits that frequently characterise young children with Autism Spectrum Disorder (ASD). However, most of the existing studies on audio-visual integration in autism rely on verbal instructions or explicit behavioural responses, and — partly for this reason — focus on high-functioning and verbal children and adults with ASD. Yet, if language development in ASD is impacted by poor audio-articulatory integration, it is of paramount importance to assess this processing component precisely in children who suffer from a language acquisition delay. Between 2 and 6 months TD infants are sensitive to audio-visual asynchrony in native speech, and preferentially gaze towards the recordings of a speaking face whose articulatory movements match the simultaneously played audio recording vs one with a mouth movement/audio mismatch (e.g. Kuhl & Meltzoff, 1984). This preferential gaze paradigm is also used in two studies that investigated multimodal integration in young (around five years of age) children with ASD, Bebko, Weiss, Demark, and Gomez (2006) and Righi et al. (2018) — and did not find clear group differences. The implicit rationale, which underlies preferential gaze paradigms in infants, is that if it is present, the sensitivity to audio-visual synchrony should be the main factor underlying the distribution of eye-fixations. However, it is unclear that one can safely presuppose that in even in TD toddlers or pre-schoolers alignment of the audio and video signals would lead to an inherent preference for the in-synch recording. Furthermore, in previous studies report gaze data as proportional fixation averages per trial, which makes it impossible to assess detailed temporal trajectories of eye-fixations.

We designed a Reinforced Preferential Gaze paradigm that overcomes biases in the previous research. In order to focus children attention on the mouth region, the video stimuli are limited to the mouth region and consist of a 5 sec recording of 3 identical consonant-vowel syllables, so that three clear articulatory movements can be easily mapped on three salient acoustic events, associated with the consonant. We also implemented a reinforcement-based anticipation method. In each trial, the stimuli presentation phase is followed by a 1 s transition blank screen, after which starts a 3 s reward phase; see Fig. 1. Rewards consist in different visually attractive animations, superimposed on the last frame of the corresponding video

(e.g. a gardener trimming the beard around the mouth presented on the screen with a lawn mower or a funny cartoon character getting out of the mouth and running away). The position of the reward can be anticipated only based on temporal alignment between the video and the audio components of the stimuli: for half of the children in each group (TD or ASD), the reward consistently appeared

on the side of the in-synch video (Synchronous version) and, for the other half, the reward consistently appeared on the side of the out-of-synch video (Asynchronous version). Consequently, anticipative gaze towards the location of the reward during the transition phase is indicative of the capacity of temporally bind the acoustic and the video signals.

Our participants were 75 3-to-5-year-olds; 31 non- or minimally verbal children with ASD and 44 TD children. Two areas of interest (AOIs) were designed and kept constant across the stimuli and the transition phases: Reward, corresponding to the exact zone where the rewarded stimuli was displayed and Non-reward, corresponding to the exact zone where the non-rewarded stimuli was displayed. Together, these two AOIs corresponded to 8.86% of the total area of the screen. A third AOI, Other, corresponded to the rest of the screen and was used for the analysis of the transition phase. Every 16 ms, and each AOI, we extracted eye-tracking data indicating whether this AOI was active or not. Stepwise multilevel regressions, with item-per-trial by item and by-participant random slopes were used to gain insight into the fixation curves in the stimuli and transition phases. Results reveal no group difference and no preferential fixation patterns during stimuli presentation. The distribution of fixations shows that children's gaze is mostly influenced by the periodic and salient mouth movement (see Fig. 2A). This confirms that preferential gaze data — especially when they are reported as collapsed proportions of fixations on a given time window — are not entirely reliable to investigate audio-visual integration in autism. By contrast, both groups demonstrated a clear preference for the Reward AOI during the first half of the transition period in both versions, viz. independently of whether the reward phase primed either the aligned or the misaligned video. Children with ASD exhibited a lower rate of fixations altogether on the transition blank screen, and particularly so for the Reward and Non-Reward AOIs (see Fig. 2B). Fixations patterns during the transition period thus offer a clear window on potential group differences in multimodal integration.

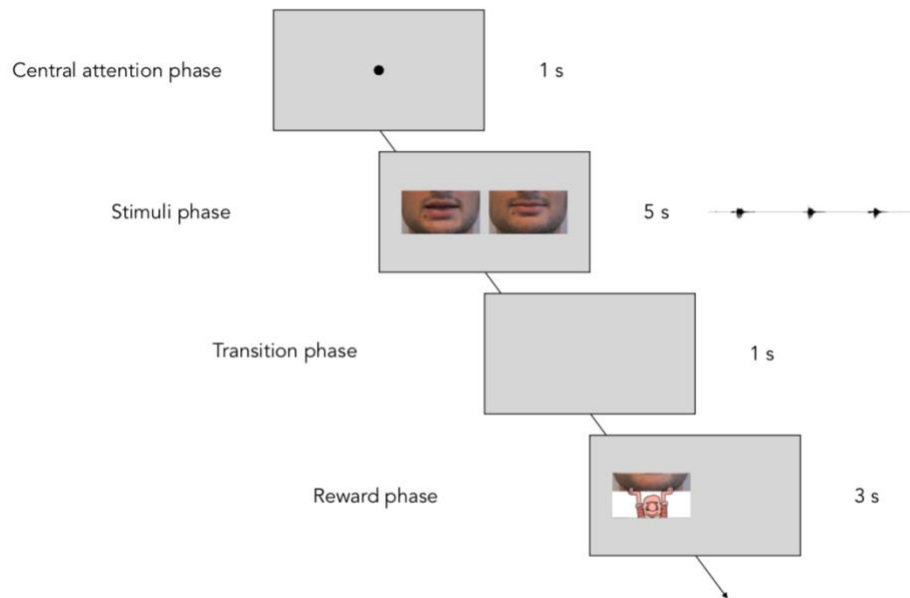


Figure 1: Complete trial course

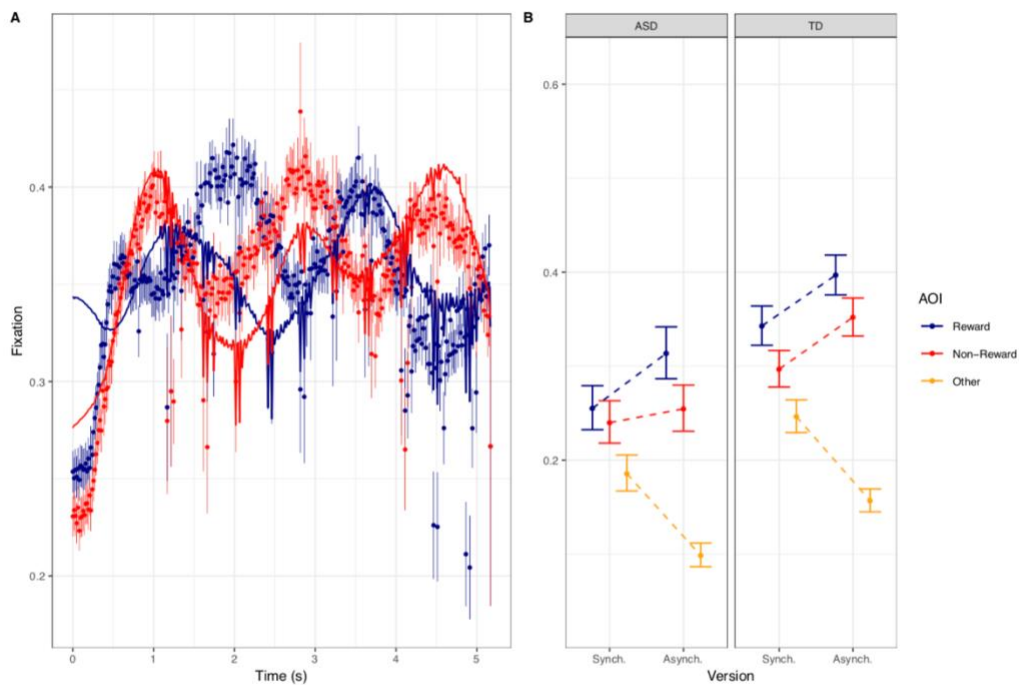


Figure 2: **A.** Stimuli presentation phase: mean fixation values (SEM) per time point (binned) and fitted fixation curves. **B.** Transition phase: effects of the Group X Version X AOI interaction; error bars represent 95% confidence intervals.

Working memory capacity, foreign language learning ability and arithmetic competence in typically-developing children, dyslexics and children with AD(H)D

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Working memory has been proposed to be a measure of a child's innate learning potential (Alloway and Alloway, 2010) given its strong link to cognitive abilities such as foreign language aptitude (Gathercole and Baddeley, 2014; Wen, Biedrón and Skehan, 2017) and arithmetic competence (Menon, 2016). Verbal working memory deficits, in particular, seem to be present in children with developmental disorders such as dyslexia (Moll et al., 2016; Schuchhardt, Maehler and Hasselhorn, 2008) and AD(H)D (Martinussen and Tannock, 2007). Furthermore, a large proportion of children with these disorders also suffer from language impairments, especially with regard to receptive skills (Helland et al., 2016).

In the present study, we tested adolescents (N=170, 104 males; age: 14.26 ± 1.72 y, range=8-17 y) of four different populations, namely typically-developing children (n=91;TD), dyslexics (n=27), children with AD(H)D (n=38) and children with dyslexia and AD(H)D (n=14; mixed group). In all children, we assessed working memory (digit span forward, backward and non-word span), language aptitude (LLAMA test; Meara, 2005) and arithmetic competence (Vogel et al., 2017). Additionally, we assessed self-perceived and other-perceived foreign language learning potential and academic performance in the form of school grades.

Statistical analyses revealed that TD children differed significantly from dyslexics and the mixed group in terms of self- and parent-perceived language aptitude. Moreover, school grades in English and German strongly differed between groups. AD(H)D children showed equal performance in all working memory tasks compared to the TD group, whereas children in the mixed group and dyslexics clearly underperformed typically developing children. With respect to foreign language aptitude, vocabulary learning and phonetic memory were significantly impaired in dyslexics and the mixed group, not in the AD(H)D group, however. The mixed group showed weakest results on the grammatical analytic tasks, whereas both AD(H)D and reading-impaired children only slightly underperformed the TD group in grammatical analytical tasks. Arithmetic fluency, in contrast, was significantly impaired in AD(H)D children and the mixed group, but not in dyslexics. It seems that dyslexic children show particular weaknesses in working memory and thus in aspects of foreign language learning relying heavily on working memory (vocabulary learning, phonetic memory). Likewise, children with a history of both dyslexia and AD(H)D underperformed typically-developing in all tasks including mathematical competence, language learning and working memory.

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Time-course activation of semantic primes in L2-English word recognition

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An important aspect of developing fluent L2 reading skills is the development of lexical retrieval skills by which words are recognized and matched with lexical entries. Previous studies on the L2-English word processing abilities of advanced-proficiency Japanese students at an English-medium university have shown them to be insusceptible to facilitation effects for semantically-related masked prime words, although lower-proficiency readers experienced delay effects for semantic primes, no matter whether or not the task emphasized semantic processing or not. As this lack of semantic facilitation under masked priming conditions has only, to-date, been found in Japanese and Chinese students of English, and as this stands in contrast to copious studies among English learners whose native languages are written with the Roman alphabet (e.g., Schoonbaert, Duyck, Brysbaert, & Hartsuiker, 2009; Devitto & Burgess, 2004; Phillips, Segalowitz, O'Brien, & Yamasaki, 2004), this suggests a script-specific effect wherein Chinese character learning during L1-literacy instruction leads to the development of qualitatively different lexical retrieval processes from alphabetically-transcribed languages. To frame it in terms of Forster's Search Model (Forster, 1976), the pre-lexical availability of semantic information in Chinese characters causes Japanese/Chinese learners not to develop the habit of opening all short-listed lexical candidates (e.g. orthographic neighbors, etc.) during the lexical search, and as such semantic information from the prime is unavailable for the subsequent word target identification. However, as advanced EFL readers obviously can access word meanings, and do so during normal reading tasks, this inability to access semantic information is likely restricted to short display times, as is the case of masked primes (which, by definition, are presented for under 80ms). The following study was undertaken to determine how long words must be presented to enable semantic priming facilitation. The study tested advanced-level Japanese students of English in a lexical decision test with a priming paradigm. Four separate versions of the test using different length of exposure of the primes, from 50 milliseconds to over 200 milliseconds, were used in testing, though each subject only took a single version of the test. Through comparison of testing results in the 4 different versions, differences in time course semantic activation became apparent, suggesting that semantic processing of primes only became possible after primes were visible (e.g., primes > 80ms), and were most robust as display time neared 200ms.

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Familiarity Based Chunking and Its Dynamics in Reading

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Chunking in language processing refers to segmenting linguistic input into small pieces (chunks), which may provide the correct sizes of information for further analyses. For example, effective chunking during reading facilitates disambiguation and enhances efficiency for comprehension. However, the mechanism of chunking is far from clear, especially in the reading given that information arrives simultaneously yet some languages such as Chinese do not have explicit cues for labeling boundaries. What factors govern chunking in reading? And what is the dynamics of chunking? We addressed these questions by manipulating the familiarity (lexical status) of chunks at distinct levels of grain-sizes in four-character Chinese strings. These four-character strings were either meaningful or non-meaningful (global level) that were composed either by two two-letter words or four individual characters (local level), yielding four conditions (two-word phrase: global true/local true, Tt; Chinese idiom: global true/local false, Tf; random combination of two-words: global false/local true, Ft; and random characters: global false/local false, Ff). The behavioral results showed that the lexical decision of familiar two-letter word local chunks was influenced by the lexical status of larger global chunk, but not vice versa, which indicated the judgement of familiar global chunks took priority over the local chunks. EEG results revealed that nested familiar chunks were first detected simultaneously at both levels and then interpreted in different order. The onset of lexical access for the familiar global chunks was earlier than that of local chunks. These behavioral and EEG results suggest that chunking in Chinese reading is based on the chunk familiarity across the linguistic hierarchy.

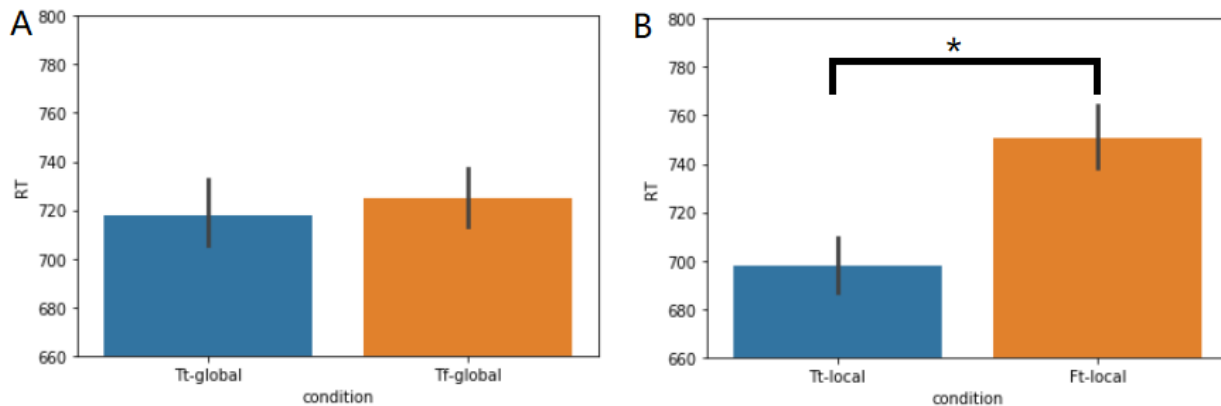


Fig 1. The reaction time results in the behavioral test. A) no significant difference was observed between the lexical decision time of global chunks with different inside structures. B) the lexical decision time for the local chunk within a familiar global chunk was significantly faster than the judgement of the local chunk without meaningful global chunk ($p < .01$). The results indicated that for the situation of local chunks nested inside a global chunk, processing priority is given to the familiar global chunk over the local chunks.

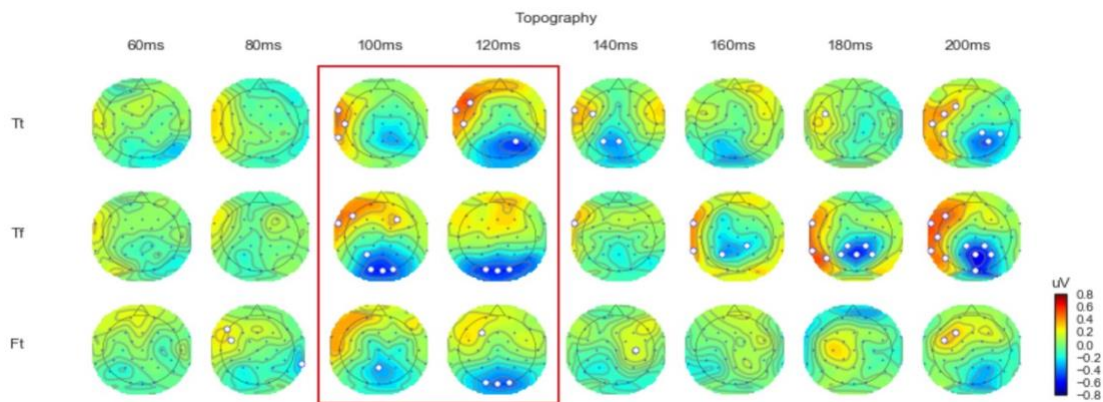


Fig 2. The dynamics of EEG topographies differs between the random strings and three types of stimuli with familiar chunks. All of them showed a similar pattern in a time window around 110 ms after visual stimuli onset, which is indicated by the red box. White circles indicated the electrodes that show significant differences. Tt: two-word phrase, Tf: Chinese idiom, and Ft: random two-words.

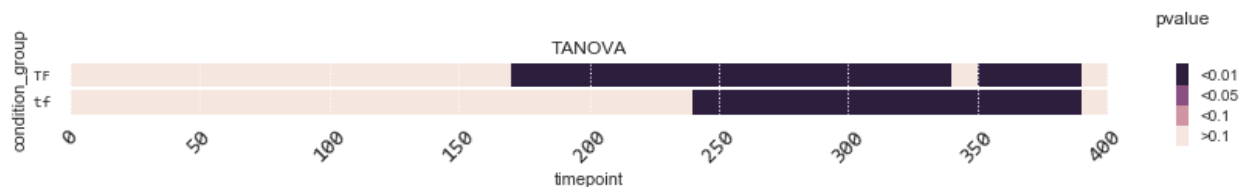


Fig 3. The time course results of the processing of global chunk (first row, 'TF') and the processing of local chunk (second row, 'tf'). The grey scales represent the p values in the Topographic Analysis of Variance between the given conditions and baseline conditions across time. The darker color means significant effects in the corresponding time windows. The comparison of two rows showed that the onset of processing of global chunk was faster than that of local chunk.