

The interactional challenge: L2 learning and use in the third age

David W. Green

University College London

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We like to talk to one another and are skilled at doing so. Conversational turns between proficient speakers, for instance, couple closely in time within the multimodal context of everyday conversation. Such synchrony strongly suggests that proficient speakers are able to manage the twin demands of understanding the current utterance and planning the next to allow fluent interaction. What of the late learner of a second language (L2)? This paper discusses the interactional challenge they face. It focusses on the processes of language control required for the learning and use of an L2. Bottom-up processes of language control, for example, allow learners to induce new constructions and offer plans for speech production. Top-down processes of language control, by contrast, bind new constructions and vocabulary into the language network and are required to control interference from the speaker's first language. Age affects the regions of the brain involved in representing the vocabulary and constructions of an L2 and the regions involved in controlling their use. Individual differences in these regions will therefore influence trajectories to interactional proficiency. But their capacity is open to change. Exercise, amongst other factors, can enhance the capacity of these regions. If so fitness may affect the trajectory to interactional proficiency. Even more optimistically learning and using an L2 may itself lead to positive adaptive changes. Tailoring learning to identified individual differences offers the best prospect for enjoyable learning of an L2 in the third age.

Introduction

Language use is a form of communicative action with conversation as the primary and multimodal site for such action. A noticeable feature of conversations between proficient speakers of a language is that the interval between successive turns can be quite short with a modal delay between them of 200 ms. - a figure that appears to be relatively constant across different languages (Levinson, 2016). One implication is that listeners may understand utterances and plan their responses during the turn of the current speaker. Indeed participants in a conversation can share utterances by switching between the roles of listener and speaker as in this example below from Purver, Cann & Kempson (2006):

Daniel: Why don't you stop mumbling and
Marc: Speak proper like?
Daniel: speak proper?

But how is it that the machinery works so efficiently? We take up this question in the next section (Interactional proficiency) in order to explore the challenges faced by late learners of an L2. At the heart of the challenge are the cognitive demands of conversation. How do

proficient speakers of a language manage the cognitive demands of conversation? Speakers can minimise demands in various ways by exploiting what they know, making use of previous utterances in a conversation and recruiting the services of the listener by look or gesture. All of these possibilities hinge on the incremental nature of speech production and comprehension. Having identified some of the cognitive demands and their management in proficient speakers we consider the challenges faced by the late learner of a second language (L2) in their trajectories to achieving interactional proficiency in their L2. In the section entitled Interactional challenge for late learners of an L2 we emphasize the nature of the language control demands that ensure the mental representation of new words and constructions and their use in the face of competition from the words and constructions of the first language. The extent to which these demands can be met leads to consideration of individual differences. We explore these differences in following section: Individual differences and the promise of L2 learning in the third age. As might be expected, regions in the brain that underlie the processes essential to the representation and use of new vocabulary and constructions show age-related declines in neural tissue. Individuals differ though in the extent of such age related declines and such differences may help predict differences in the trajectories of late L2 learners to interactional proficiency in L2. Interestingly, the integrity of neural tissue can be enhanced even in older individuals. Non-invasive neuroimaging data indicate that certain life-style factors such as exercise, and also attention-demanding action video-games, can reliably enhance the integrity of neural tissue with a correlating impact on skilled performance. Conversely, other factors such as chronic stress can impair the integrity of neural tissue. Specific research is needed to identify how the integrity of neural tissue relates to language learning in the third age. But by identifying brain markers relating age-related changes in neural tissue, and relating these to behavioural measures, we suggest that it may be possible to envisage tailored programmes so that third-age learners can reach interactional proficiency and enjoy conversations in their L2. We review the arguments presented and consider current limitations of our understanding in a concluding section.

2.0 Interactional proficiency

Speaking, like any other complex sequential action is guided by a plan that precedes its execution (Lashley, 1951). The production of an utterance plan imposes a cognitive demand. We grant the principle (e.g., MacDonald, 2013) that in conversations the processes of speech production serve to minimise the cognitive demand of generating a speech plan. Incremental (i.e., left to right) utterance plans allow speakers to interleave planning and execution and so permit them to start speaking before utterance planning is complete. Words or constructions that come most readily to mind can be recruited. These may be ones that are most accessible from long-term memory or may be ones that have just been used or "primed" whether by the current speaker or by the addressee in their previous turn. Reuse of words or phrases is also efficient in allowing participants to adopt common referring expressions for the objects and events that are the current topic of conversation. It prompts alignment across linguistic levels (e.g., Pickering & Garrod, 2013). Where a speaker finishes the executable portion of the plan before the next section is ready, they can hold their turn by lengthening words, or fill the pause with an "um" or "er". Alternatively, they can recruit the services of the current listener

by utilising the multimodal context of everyday conversations. They can, for instance, gesture to signify the intended referent, in the event they cannot retrieve a word, or point to the intended referent in their shared perceptual world.

Languages provide different ways to convey the meaning of an utterance. Such flexibility in the words or constructions that can be used is also helpful in maintaining fluency. But this flexibility comes at a cost. Non-selected alternatives must be rapidly suppressed in order to ensure that selected words are articulated in the correct serial order. Typically, the neural mechanism successfully suppresses any non-selected alternatives in line with a “winner-takes-all” principle – a principle that also applies to non-verbal motor actions (Bohland, Bullock & Guenther, 2009; Grossberg, 1978; Houghton, 1990).

Given that conversational participants are able to synchronise their turns effectively, and even share utterance production, it follows that listeners must incrementally construct a semantic representation aligned to that in the mind of the speaker. From a linguistic point of view, the processes of utterance interpretation must work with incomplete word strings that match the incremental nature of speech production. Interestingly, neuroimaging research suggests that the neural regions involved in speech comprehension overlap with those involved in speech production (Silbert et al., 2014). Such overlap suggests that the processes of production may even help predict upcoming content (Pickering & Garrod, 2007).

In summary, the conversational synchrony displayed by proficient speakers of a language is sustained by the incremental nature of both speech production and speech comprehension and underpinned by the reuse of constructions and words that are part of participants’ shared knowledge of the language. Participants in a conversation can also explicitly recruit help from one another and exploit the multimodal nature of the conversational context. Implicit in this characterisation are the processes of language control: top-down processes of control select what is to be said and can guide the interpretation of what is said where there is ambiguity or uncertainty; bottom-up processes of language control can prime expressions to constrain the speech plan. But top-down processes of control are involved here too. After all what might be primed by a previous stretch of speech may not correspond to how the current speaker wishes to express themselves. We think it preferable therefore to say that top-down processes of language control “allow” the production of primed forms and constructions.

Given this sketch of the processes involved in interactional proficiency in proficient speakers, what challenges to such proficiency await the late learner of an L2? We discuss these in the next section.

3.0 Interactional challenge for late learners of an L2

In a speaker’s native language, top-down and bottom up processes of control collaborate to produce and execute an utterance plan based on existing lexical concepts and constructions. Bottom-up processes of control elicited by utterances of a conversational partner may also trigger inductive processes to account for unexpected content. These two broad classes of control process play an important role in learning an L2. They operate within the multimodal

context of conversational exchange and so allow speakers to gesture and point to referents in the world and recruit, where possible, the language knowledge of a native speaker to repair their utterance. If we track such exchanges over time we might see reduced reliance on this kind of support associated with dysfluency in speech production combined with an increase in co-speech gestures recruited for expressive purposes. Top-down and bottom-up processes adapt the language network though their functional contribution may change with learning. For example, at an initial stage, top-down processes of language control may predominate. These use information from explicit instruction (or metalinguistic knowledge, Jessner, 2008) to adapt the language network in order to represent novel L2 vocabulary and constructions. Once adapted, and used (e.g., to make requests or answer questions in L2) bottom-up processes of control based on the speech of an L2 speaker may trigger inductive processes to identify the sense of a novel word or the form of a novel construction. Evidently, change in the language network is necessary to allow a speaker to converse but it is not sufficient. Speakers must also be able to control the outputs from the adapted network. In the next part of this section we consider both the nature of the network changes and the control processes required.

3.1 Representational change and bilingual language control

Learning new words and constructions in L2 entails changing the existing network of lexical concepts, lemmas and word forms (Levelt, Roelofs & Meyer, 1999). Language control processes that involve attention and cognitive control must therefore recruit memory. Following Hartsuiker, Pickering and Veltkamp (2004) we can visualise a change in the network such that new items (lemmas and word forms) and constructions are linked to distinct language nodes: one for the native language (L1) and one for L2. Such links tag each item and construction according to the language (see De Bot & Jaensch, 2015 for an alternative view). In the case of syntactic constructions or frames, “combinatorial nodes” capture the slots that need to be filled by lexical items. Where two languages share common constructions (e.g., active or passive forms) then the relevant combinatorial node can be linked to each of the language nodes- effectively capturing the typological proximity of the two languages. For example in the case of Spanish and English (examples from Hartsuiker et al., 2004), the combinatorial node for the active construction (as in the Spanish: “El taxi persigue el camion” and the English: “The taxi chases the truck”) would be linked to a Spanish language node and an English language node. Representing vocabulary, at least where there are common lexical concepts, involves linking a pre-existing lexical concept to a new lemma (to capture its syntactic properties such as the word's grammatical gender) and linking that lemma, tagged by an L2 language node, in turn to a novel word form.

Tagging items and constructions via links to a language node is a form of pattern separation. Pattern separation helps ensure that the retrieval of syntactic constructions and lexical items is context-sensitive. Tagging a common construction for use in L2 allows it to bind with L2 lexical items and also allows its continued use in L1 via its link to the L1 language node. Once a given construction (or syntactic pattern) is learned then the processes of pattern completion are also relevant. In the case of speech production, for instance, retrieval of part of a construction can elicit retrieval of the whole and so allow the

incremental construction of the utterance plan. In the case of comprehension, by contrast, pattern completion can trigger predictions about forthcoming content. On this way of thinking, both pattern separation and pattern completion processes contribute to interactional proficiency.

As noted earlier, representational change is a necessary but not a sufficient condition for L2 speech production. In terms of interactional proficiency, L1 word forms and constructions are likely to be more accessible than those from L2 at least in the early stages of L2 learning or in a non-immersed language environment. Their relative accessibility means that they could enter the speech plan unintentionally and disrupt fluency. In order to limit that possibility, use of an L2 requires controlling interference from the dominant L1. How might this be achieved? Conceivably, such interference is minimised by suppressing the entire L1 language network. However, experimental research strongly suggests that L1 representations remain active even when only L2 is in use (see Kroll et al., 2015 for a review). Joint activation, for example, can lead to increased dysfluency in speech relative to monolingual speakers both for immersed non-native speakers and for L1 attriters immersed in an L2 environment (e.g. Bergman, Sprenger & Schmidt, 2015).

The intention to speak L2 (via top-down control) may then bias but not fully suppress the L1 network and so control schemes that emphasize the activation and deactivation of entire languages (e.g., Grosjean, 1998; Muysken, 2000; Williams & Hammarberg, 1998) may not adequately characterise the process of language control. Rather additional, top-down control processes are required that target the output of the language network (Green, 1986; Green, 1998; Green & Abutalebi, 2013). Such control is, in a sense, external to the language network. Under a control scheme of this type, and consistent with the experimental evidence, items and constructions from either language can become active, because they match the intended message to some degree, but activated items and constructions competing to form the speech plan can still be constrained to ones that match the goals of the speaker, subject to the individual's ability to control interference. The mechanism required is likely to be identical to that which rapidly suppresses alternative, non-selected items, in the speech plans of monolingual speakers. It inhibits such items only once they become active and so implements "reactive inhibition" (Green, 1998). Given that performance on cognitive control tasks is known to decline with age, the interactional challenge for late learners of an L2 combines two kinds of demand: memorial demands to achieve representational change of the language network and control demands to use the adapted network. We explore individual differences that may shape response to these demands in the next section.

4.0 Individual differences and the promise of L2 interactional proficiency in the third age

Individual differences are likely to permeate the learning of an L2. Consider the need to perceive and produce novel speech sounds. Most of us struggle to do so but some find it easier than others. In young adults, differences are traceable to an auditory processing region (left Heschl's gyrus) and to the connectivity of this region to other language sensitive regions (e.g., Golestani & Pallier, 2007). Along with other cortical regions, the cerebellum, is also

involved in the overt articulation of speech sounds (e.g., Durisko & Fiez, 2010; Stoodley & Schmahmann, 2009) and may feature more prominently as the sound patterns become overlearned. Age affects the learning of a new skill. As we age there are widespread declines in regional grey matter and in the integrity of the white matter tracts that interconnect them (e.g., Colcombe et al., 2003). In addition to affecting the perception and production of novel speech sounds, such age-related declines are likely to exaggerate individual differences across a wide range of the cognitive control and memorial skills required in learning and using an L2.

We know of no in-depth studies relating individual variation in the neuroanatomy of the brain to language learning in the third age but there are data relating markers for age-related declines in the brain to performance on tasks that tap core features of the control and memorial processes important for language learning and use. A study by Hedden et al. (2016) will serve to illustrate. The researchers recorded the behavioural scores of 186 adults aged between 65-90 years of age on tasks that tap processing speed, cognitive control and episodic memory. Based on neuroimaging data from the same participants they assessed the relationship between a set of brain markers of age-related declines and these behavioural scores. For example, they scored overall white matter integrity and the volume of various structures involved in cognitive control (the putamen and caudate of the basal ganglia) and memory (the hippocampus). In their analyses they distinguished between the variance in behavioural scores explained by the brain markers taken together (shared variance) and the variance unique to each one. Roughly 50% of the variance in the behavioural scores reflected variance shared amongst two or more brain markers. In line with their established roles, hippocampal volume explained more variance for the episodic memory tasks whereas basal ganglia volume explained more variance in tasks tapping processing speed and cognitive control. Additionally, white matter integrity was more explanatory in accounting for processing speed and cognitive control.

The important point for present purposes is that such research suggests that we might be able to identify brain markers associated with the learning of a second language in older adults. On the supposition that learning an L2 involves a coordination between processes of language control and memory, it would be especially helpful to have markers for age-related decline in regions involved in language control (see Abutalebi & Green, 2007; Green & Abutalebi, 2013) and markers for age-related declines in regions representing new vocabulary and constructions. There are some promising possibilities.

Under intense and effortful learning conditions (a translation school for young soldiers) there are changes in regions involved in representing vocabulary (e.g., the hippocampus) and in the frontal regions of the cortex regions managing interference and articulatory demands (Mårtensson et al., 2012). Interestingly, right hippocampal volume increased most for those better at interpreting. This result is in line with earlier research identifying hippocampal response (plasticity) in the learning of vocabulary (e.g., Davis & Gaskell, 2009). It also relates more generally to research establishing the role of hippocampal regions in distinguishing memory representations- the process of pattern separation (Hunsaker & Kesner, 2013). Indeed performance on a non-verbal task (a delayed match to

sample test involving confusable novel objects) that tests skill in pattern separation predicted change in grey matter structure in a right hippocampal region during a few weeks of novel foreign vocabulary learning in young adults (Bellander et al., 2016). Hippocampal responsiveness then may be a contributor to individual differences in vocabulary learning and such responsiveness may even be indexed by performance on a non-verbal test of pattern separation. With age, there is a decline in hippocampal responsiveness (Driscoll et al., 2003) –a decline that may increase the difficulty of learning a new language. Hippocampal involvement in the episodic learning of new words appears well-established but other regions (anterior temporal and parietal areas) are involved in the slower integration of words into longer-term declarative memory. Sleep acts as a potential mediator (Davis & Gaskell, 2009). All these structures are also subject to age-related declines. Predicting variation in the long-term retention of L2 vocabulary will then reflect the integrity of these substrates. From a practical point of view, a useful behavioural indicator here may in fact be performance on an associative memory task using L1 words (see Bellander et al., 2016).

One other result with young adults is worth mentioning because of its bearing on vocabulary learning. We supposed above that bottom-up processes of language control can trigger processes that induce the meaning of a new word associated with a novel word form. It turns out that the efficiency of this process reflects the coupling of the language sensitive regions in the brain with evolutionarily-older regions involved in reward and motivation. Strikingly, prior differences in the connectivity of these regions are predictive of the ease with which young adults learn the meanings of novel words from sentences in their L1 (Ripollés et al., 2014). We should expect such findings to extend to older adults and to the learning of novel words and constructions in the L2. Conceivably though in the older learner reduced connectivity will affect the motivation to learn such that those with reduced connectivity are less motivated to learn an L2 in the first place or to put the time in to learn it (see also data reported in Bellander et al., 2016). However, evidence of widespread plasticity in the older brain in response to challenge suggests that we should be wary of presuming that prior differences in connectivity indicate hard constraints on a person's ability to learn a new language. Rather, isn't it possible that pleasure in being able to converse in a new language alters such connectivity?

What of the learning of new syntactic constructions in an L2? Much is unknown about the nature of individual differences in learning the syntax of an L2 even in young adults (see Steinhauer, 2014, for a review of the recent studies, and Caffara et al., 2015 for an analysis of the factors that affect sensitivity to different aspects of L2 syntax). Longitudinal studies of the learning of an L2 are arguably the gold standard if we want to study individual differences in the learning of syntax and we lack these in the context of older adults (see Tanner et al., 2013 for work with young adults). However, as matters stand, constraints on the learning of L2 syntax in young adults seem more likely to reflect properties of the learner and the contexts of learning rather than a closure of some critical or sensitive period for language acquisition. It is worth noting that the brains of some neurologically normal older people operate with the same efficiency as younger brains and that across the age range from 20-70 years there is no evidence of discontinuity (Lindenberger, 2014; see also Sun et al., 2016).

The data in the study by Lindenberger came from a working memory task but are there any reasons to expect some discontinuity in the learning of L2 syntactic constructions in older adults? Just one perhaps: later L2 learning occurs in the context of age-related declines in the left-hemisphere regions involved in processing syntax.

In monolingual speakers these left-hemisphere regions show decreases in grey matter and reduced connectivity (Shafto & Tyler, 2014). However, there is preserved sensitivity to syntax. Such perseveration plausibly reflects continued use of the “residual” left hemisphere system rather than the recruitment of a region in the right hemisphere. How is an L2 represented and processed? In young adult bilingual speakers, the bulk of evidence favours the idea that the processing profiles of an L2, together with its neural substrate, show a degree of convergence with those of native L1 speakers of the language (Green, 2003)¹. Convergence is necessarily partial with respect to the processing profiles of the native speakers of each language because of the mutual influence of the two languages on one another. Indeed, consistent with the notion that bilinguals also have to manage potential competition with their L1, comprehension in L2 yields increased involvement of regions involved in cognitive control (Weber et al., 2016). Meeting such control demands might be more difficult for older learners especially during speech production. Speech production imposes control demands on the cortical and subcortical regions (e.g., basal ganglia regions) that update, maintain and output a constructed sentence plan (Kriete et al., 2013; Argyropoulos, Tremblay & Small, 2013). Speaking an L2, increases demands on these regions, and their connections, because this network of regions must also bind language specific word forms to the selected syntactic construction in the face of competition from L1 representations (see also Stocco et al., 2013 for a related view). This challenge is potentially problematic because the regions, and the white matter tracts connecting them, suffer age-related declines (Colcombe et al., 2003; Bo et al., 2014). On this basis, we might reasonably infer that use of an L2 will be more effortful and reveal greater dysfluency in older learners.

The precise extent of dysfluency will reflect individual variation in age-related decline. Behavioural measures, such as performance on a non-verbal, flanker interference task (Festman & Münte, 2012), predict inadvertent L1 intrusions in proficient adult bilingual speakers and so may provide a clue to the degree of dysfluency a person may experience in learning an L2. Behavioural tests that target individual differences in reactive inhibition specifically (e.g., Morales, Gómez-Ariza & Bajo, 2013) may also prove particularly predictive given that bilingual speakers must also rapidly suppress any non-selected L1 representations. In the absence of longitudinal studies of the learning of an L2 in the third age, we can only assert the claim that individual differences in age-related declines in the integrity and connectivity of brain regions, will affect the learning trajectory. But are there factors that can affect age-related declines and so either facilitate or impair the trajectory to L2 interactional proficiency? Yes there are: we consider these next.

4.1 Interventions

Stress is one factor that affects age-related declines in neural tissue. It affects hippocampal function and induces deficits in declarative memory. When prolonged, stress also affects the

network of cortical and subcortical regions involved in cognitive control inducing less flexible behaviour (see Sousa, 2016 for a synoptic view). Chronic stress may then be an impediment to the learning and use of an L2 in older adults for whom these regions and their interconnections are already compromised. If that is so, individuals such as refugees from war living in a new culture with an urgent need to learn its language, may be the ones for whom learning an L2 will be most problematic.

Although prior anatomical differences, and those compounded by life events, may place constraints on learning, they do not preclude it. Instead they invite us to consider interventions that can circumvent such constraints. For social and economic reasons, there is considerable interest in interventions that may be neuroprotective of age-related declines. Some of these studies are pertinent here. Long-term aerobic exercise reverses age-related declines in hippocampal volume in older adults and improves memory for spatial relations (Erickson et al. 2011)². The precise mechanisms of such an effect are not established but if exercise enhances pattern separation skills then it may also improve the rate of L2 vocabulary learning in older adults including those perhaps suffering from chronic stress. Exercise also affects cognitive control – indeed the effects of exercise interventions in older adults are more marked on tasks with increased demands for cognitive control (e.g., Hillman et al., 2008; Smith et al., 2010). Notably, exercise interventions improve performance on the flanker interference task (e.g., Colcomb et al, 2004; Voelcker-Rehage & Nieman, 2013). Further, behavioural improvement is accompanied by more efficient processing in frontal regions of the brain that resolve conflict. The benefits of exercise are not restricted to aerobic exercise. Coordination training (i.e. exercises involving balance and eye-hand coordination) has also proved effective in improving the control of interference and in improving the efficiency of the brain regions involved (Voelcker-Rehage & Nieman, 2013). Given the data of Festman and Münte (2012, cited above), these studies suggest that aerobic exercise, or coordination training, may limit the experience of between-language interference.

Nor is physical exercise the only factor that may reduce age-related declines in brain regions. It seems that playing action videogames is also neuroprotective (see Bavelier et al., 2012). It certainly enhances a number of processes (e.g., working memory and sustained attention) in older adults (Anguera et al., 2013) that are relevant to learning an L2.

We are not aware of studies that examine the effects of long-term exercise on L2 language learning in adults. Such interventions may prove helpful as a precursor, or concomitant intervention, to the actual learning of an L2 but surely the very act of learning and using a second language is itself likely to alter age-related declines? It provides, doesn't it? precisely the kind of challenge to induce relevant changes. Whilst long-term active use of two languages seems neuroprotective (e.g, Bialystok, Craik & Freedman, 2007); Alladi et al., 2013) we lack studies of the potential neuroprotective effects of the learning and use of an L2 later in life. Assuredly, individuals will differ in their ability to respond adaptively (Lövdén et al., 2010) but preliminary behavioural data do indicate adaptive change. A short-term intensive L2 learning course in older adults enhanced skills in sustained attention (Bak, Long, Vega-Mendoza and Sorace, 2016). Taken together with other research which shows that sustained attention is mediated by the coordinated activity of cortical-subcortical and

cerebellar regions (Rosenberg et al., 2016), language learning and use in older adults may exert widespread effects that are neuroprotective. Longitudinal studies are required to test such an expectation.

4.2 Tailoring interventions to achieve L2 interactional proficiency

We have considered the challenges faced by late learners of an L2 arising from age-related declines in the language control and language-sensitive regions of the brain. Individuals will vary in their ability to circumvent the different types of challenge. For example, dependent on the language to be learned, perceiving and producing novel speech sounds may prove especially problematic for some. For others, learning and retaining new words may be problematic. Ideally then it would be useful to have indicators of the particular difficulties that individuals may face and design interventions that can support their learning.

Neuroimaging data can provide brain-markers of decline but such data are currently too expensive to collect on a grand scale. Refining behavioural tasks to achieve sensitivity to these declines and using these to track changes over the course of L2 learning and use seems the most practical approach.

How might the learning process itself be shaped? Exercise (and sleep) may be component of any programme but the language learning process must itself be shaped. For example, in learning object names is it better to hear the name of the depicted object and repeat it or to see the object and attempt to name it and only then hear the correct name? Consistent with the idea that there are "desirable difficulties" in language learning (Bjork, 1999), experimental research confirms that it is more efficient for a learner to produce the name of a picture and then hear its correct name than to merely repeat its auditorily presented name (Kang, Gollan & Pashler, 2013). We learn optimally through error-correction. A programme tailored to the individual might begin with objects and events that reflect the person's interests (e.g., soccer; cooking; gardening). The same error-correction procedure may also facilitate the perception and production of novel speech sounds in the first place and cater for individual differences in the difficulty of such perceiving and producing these. For instance, one part of the procedure might involve learners attempting to produce the target speech waveform for the pronunciation of a novel letter combination in L2. With a device such as a mobile phone individuals can achieve a desired degree of mastery at their own pace.

Ultimately though how language learning is shaped depends on the goal of the enterprise. We take the goal to be interactional proficiency in the multimodal context of conversation. We leave open "quantifying" interactional proficiency. It maybe that conversations that work for the parties involved converge on the modal 200 ms value of the interval between successive turns but it would be useful to capture the intersubjective value of a conversational interaction. In an everyday context, if we can avoid circularity, we might say that interactional proficiency serves to optimise the intersubjective value of the conversation for the parties involved. Regardless of how we might measure interactional proficiency (cf. Hulstijn, 2011), if we take interactional proficiency as the goal, conversational interactions have pride of place. In terms of individual differences, conversations oriented towards the learner's personal interest, provide a starting point on the

trajectory to interactional proficiency. It is possible that the technology of virtual worlds, that enables multimodal interactions, may supplement face to face interactions with actual speakers, and allow learners to converse on topics of interest to them and gain confidence and experience in turn-taking in L2. In one hypothetical scenario, guided by an error-correction approach, learners move from hesitant speech incorporating pointing to objects or events in the depicted world for which they currently lack correct L2 expressions to more proficient conversational exchanges where gestures serve other purposes. In another scenario, emphasising the intersubjective value of the interaction, an older L2 learner may, through reasons of age-related declines in neural tissue, continue to be hesitant but nonetheless participate in enjoyable L2 conversations with their new friends (or carers) because conversation is a joint effort.

5.0 Conclusion

Conversation is a key site of language use and we considered what challenges the late learner of an L2 faces to achieve interactional proficiency. The multimodal context of conversation offers opportunities for learners of any age to bootstrap their language by gesture or by interleaving L1 expressions when talking to a bilingual speaker. All learners also face challenges of language control both in order to represent novel words and constructions and to use them. But the challenge of learning an L2 in the third-age is compounded by age-related declines in the neural regions and interconnections that meet these representational and control demands. Age-related declines reveal individual variations as indicated by brain markers and by behavioural tests for memory and control. Stress can amplify decline such decline and aerobic exercise or playing action videos reverse it. Learning a second language may also reverse it. Further research is needed to develop sensitive tests that bear on the precise control and memorial demands of learning an L2 in the third age but individualised learning programmes are feasible. From a research point of view, we need to track changes on these tests as learners become more proficient in order to validate their relevance. L2 learning programmes, tailored to the individual, may be most efficient in aiding late L2 learners achieve interactional proficiency when combined with a language learning virtual world that permits learners to exploit the multimodal contexts of conversation. However the notion of interactional proficiency itself requires critical exploration. The intersubjective value of a conversational exchange may be the place to start so that we do not rule out exchanges, that although hesitant and dysfluent in certain ways, work for the parties involved.

Note 1 Some hold that whereas the acquisition of a native language recruits a network common to motor skills (a procedural network), learning a second language, at least in adults, recruits one subserving the learning of vocabulary, a declarative network (e.g., Ullman, 2001). However, on theoretical grounds it is more reasonable to suppose the recruitment of a common substrate with the native language from the start with a degree of neural convergence to the processing patterns of native speakers as proficiency increases (Green, 2003). Consistent with a common substrate, studies of artificial grammar learning in young adults indicate evoked reaction potential profiles in common with the processing of native syntax (e.g., Friederici et al., 2006; Wilson et al., 2011; see also Ding et al., 2016). Studies of proficient adult bilingual speakers also show common patterns of sentence processing as native speakers (e.g., Bowden et al., 2013)

Note 2 The dentate gyrus (a region in the hippocampus) is implicated in pattern separation and this region generates new nerve cells even in adults. Exercise in the Erickson et al. (2011) study also increased a mediator for neurogenesis and so speculatively, increased fitness may aid vocabulary learning. Alternatively but not exclusively aerobic exercise may improve angiogenesis.

6.0 References

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