The effects of first exposure to an unknown language at different ages[1]

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Wir konfrontierten 152 Schweizerdeutsch sprechende 10-90-Jährige mit einem 7-minütigen kontrollierten, aber natürlich gesprochenen Wetterbericht auf Mandarin-Chinesisch, um zu testen, ob sie phonotaktisches Wissen nach minimaler Exposition ableiten können. Mit einer lexikalischen Entscheidungsaufgabe wurde untersucht, ob die ProbandInnen Wörter von Nicht-Wörtern unterscheiden können und aus der Exposition abgeleitetes phonotaktisches Wissen auf neue Einheiten der Sprache anwenden können. ProbandInnen lehnten Konsonanten-Cluster leichter ab als unmögliche CVC-Silben. Dabei bemerkenswert ist, dass die CVC-Struktur sowohl in der Erstsprache der Teilnehmenden, als auch im Chinesischen möglich ist, und somit die Erkenntnis, dass die spezifischen Silben (CV_nasal/plosive) im Chinesischen nicht möglich sind, aus dem kurzen Fremdsprach-Input abgeleitet werden musste. Es gab keinen Alterseffekt für die korrekte Ablehnung der CVC-Silben, was darauf hinweist, dass sich die getestete Fähigkeit nicht mit dem Alter verändert. Diese Resultate bestätigen Ergebnisse aus der Forschung zur Lernbarkeit künstlicher Sprachen und belegen eine starke menschliche Fähigkeit zum Erwerb abstrakter Information nach minimalem Kontakt, nicht nur mit künstlicher, sondern auch mit natürlicher gesprochener Sprache. Ausserdem scheint diese Fähigkeit über die Lebensspanne konstant zu bleiben, was herkömmliche Annahmen bezüglich Alterseffekten im Zweitspracherwerb in Frage stellt.

Stichwörter: Alter, Zweitspracherwerb, phonotaktisches Lernen, erste Exposition, ab initio Lernen, minimaler natürlicher Sprach-Input

1. Introduction

It remains a hotly debated topic what adult learners are or are not capable of in language learning, and especially what they can do with input. A fundamental question is how adults break into a foreign language system at first contact, when they have no pre-existing knowledge of the new language to draw on, and what they can learn. The study we report on asks two main questions: First, how quickly can adults learn to distinguish sound regularities in natural language

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input? Second, if adults can extract abstract phonotactic knowledge, does this ability change across the lifespan? Do adults or children learn these things more easily?

2. Background

Many authors (e.g. Christiansen *et al.* 1998; Klein 1986) have noted that the second language (L2) learner's task consists of different sub-tasks, such as comprehending the utterance, encoding statistical regularities, and integrating these regularities. How the learner tackles these tasks is still vividly disputed and has led to different approaches and theories.

2.1 From language input to learning

In an illuminating series of studies, Carroll (Carroll 2002, 2004; Carroll & Widjaja 2013) has debated the role of input and the work a learner must perform on it, discussing, for example, the difference between learning and 'mere' memorization. This line of investigation is related to previous research on the possible difference between 'input' and 'intake' (e.g. Corder 1967; Skehan 1986), the role of attention and noticing differences (e.g. Ellis & Sagarra 2010), individual differences (e.g. Sparks & Ganschow 2001), and the difference between intentional and incidental, explicit and implicit L2 learning (e.g. DeKeyser 2003; Hulstijn 2003; Saffran *et al.* 1997).

One problem with examining learners' work on the input concerns control of learners' prior experience and knowledge. Artificial and statistical language learning studies have solved this problem by controlling the language input. They typically present short strings of often-repeated syllables and then go on to test whether learners have detected regularities in the input (e.g. Saffran *et al.* 1996; Peña *et al.* 2002; Perruchet & Poulin-Charronnat 2012). In this way, transitional probabilities between syllables are the only cues for word segmentation, for example. This design allows researchers to test whether child and adult learners use this kind of information or not. Other studies have constructed small artificial languages to test the learning and memorization of grammatical rules and words (Friederici *et al.* 2002; Abutalebi 2008; Abutalebi & Green 2007; Fitch & Friederici 2012). Artificial and statistical language studies have contributed enormously to our understanding of how L2 learning proceeds. However, one restriction is that they usually use very small samples of a language and often train learners prior to the task, for example through repetition, to guide the segmentation process (e.g. Friederici *et al.* 2002; Tamminen *et al.* 2013 for training with artificial language stimuli; Chambers *et al.* 2003 for repetition). This is hardly comparable to naturalistic L2 acquisition at first contact. A few recent studies (Hayes-Harb 2007; Carrol & Widjaja 2013; Shoemaker & Rast 2013) have used natural language and trained participants on these stimuli. In the study by Carroll & Widjaja (2013) participants were trained and tested on L2 (Indonesian) number constructions that largely differ from the respective L1 expressions. The results showed that some adult learners were able to acquire and internalize the constructions after only two training trials. Shoemaker & Rast (2013) also examined the learnability of phonological forms at the very initial stages of learning. The study examined the effect of utterance position and transparency of lexical items in classroom input. Their results suggest that as little as 1.5 hours per week of classroom instruction suffice for learners to begin to extract words from natural L2 speech. The studies mentioned trained their subjects on the unknown language stimuli. The question therefore remains what adults would be able to do without any prior training on natural language stimuli.

In a different strand of research, classroom studies have used naturalistic settings to examine L2 learning of natural language at first contact. They examined effects ranging from a few hours of highly controlled input to six years of classroom instruction (e.g. Muñoz 2006; McLaughlin *et al.* 2004; Rast 2008; Shoemaker & Rast 2013). However, although natural language was used, it has been pedagogically prepared to help the learners break into the system. Again, the question remains what the learner could do without any assistance, and also how well controlled the input to learners really is.

To tackle this latter problem, a series of studies have exposed learners to seven minutes of natural, continuous, but fully controlled Mandarin Chinese (Gullberg *et al.* 2010; Veroude *et al.* 2010; Gullberg *et al.* 2012). They have found that Dutch learners can recognize words, identify relevant noun meaning and map it onto forms after this brief exposure. In an fMRI-study, they have also found structural neurological adjustments in functional connectivity between brain regions implicated in language processing after such brief exposure (Veroude *et al.* 2010). These studies suggest that adults are capable learners even if input is 'naturally' rich (meaning consisting of many types and few tokens) and as brief as seven minutes.

2.2 Age and Multilingualism

The role of age and age of acquisition for the success of L2 learning is a permanent topic of dispute, especially in terms of the acquisition of L2 phonology. The so-called Critical Period Hypothesis (CPH) has both supporters (e.g. Lenneberg 1967; Johnson & Newport 1989; Elman 1993; Weber-Fox & Neville 1996; DeKeyser 2000; Kuhl 2004) and doubters (e.g. Singleton 2005; Neufeld 1977; Friederici *et al.* 2002; Hakuta *et al.* 2003; Stein *et al.* 2006; Dimroth & Haberzettl 2012; Carroll & Widjaja 2013). Supporters of the CPH argue in favour of a critical point in development where the unaccented acquisition of L2 phonology is no longer possible. Lenneberg (1967), for example, suggested the age of twelve as the turning point, while Kuhl (2004) proposed the age of nine months to be the point beyond which the perceptual sensitivity towards non-native speech sounds is reduced. This developmental turning point is reflected in a change in learning strategies in children relative to adults (compare e.g. DeKeyser 2003), which is often used as an argument in favour of early foreign language learning (e.g. Abrahamson & Hyltenstam 2009). Adversaries of the CPH, on the other hand, have provided evidence to call into question the claim that adults are not able to fully master the phonology of a 'late-acquired' foreign language. Friederici and colleagues (2002), for example, showed that adults' brain activation when processing a trained artificial language resembles the activation of adults processing their native language. In the Barcelona Age Factor- (BAF) study, Muñoz (2006) also supported the notion that it is the amount of time spent learning a language that matters rather than the starting age (compare also Carroll & Widjaja 2013, mentioned above).

Discussions about age effects often focus on ultimate attainment, 'end states' and nativelikeness instead of on the process of development or the rate of attainment (e.g. Birdsong 2006 for overview). In a time of growing multilingualism this focus on nativelikeness probably needs to be reconsidered and the importance of other skills, such as executive control processes required for language switching, should be examined in more detail (e.g. Bialystok *et al.* 2004; Abutalebi 2008; Abutalebi & Green 2007; Adank & Janse 2010). Multilingualism and globalisation also make the study of a broader age-spectrum increasingly relevant (compare the notions of multicompetence by Cook 1992; Klein 1998; the bilingual turn by Ortega 2013). In much recent work the influence of cognitive and social maturity is seen not as a hindrance but as a positive influence on language learning.

In sum, the effects and constraints of age on acquisition and input processing remain an extensively debated topic in the literature. This study contributes new information in the following ways: Firstly, we examine participants across almost the whole life span. Secondly, we test the ability to implicitly acquire (i.e. without instruction and directed attention) phonotactic information after only seven minutes to capture the very initial state of learning at first exposure. Thirdly, we use continuous natural audiovisual speech to mimic the real life situation as closely as possible.

3. Methods

3.1 Participants

We recruited participants by means of a language background questionnaire. In total, nearly 400 people filled out this screening questionnaire. 168 participants were tested, of which 152 went into the analysis (84 females; 68 males), between the ages of 10 to 86 years along an age continuum. We recruited 20 participants each in 9 different age bands to ensure a balanced distribution along the life span (10-12, 15-16, 20-29, 30-39, 40-49, 50-59, 60-69, 70-79, 80+)[2]. In each age band, there remained a minimum of 16, and a maximum of 21 participants (except for the 80+ band with only four participants). The inclusion of children (10-16 years) at one end of the continuum meant that we could not easily control the sample for socio-economic status (operationalized as having at least the Swiss Federal matriculation as an academic degree). For the elderly (60-86 years) it would also have been difficult to find subjects meeting this criterion since only around 10% of the Swiss population acquired this degree before the 1980's (BFS 2010). All participants provided written consent (in the case of children, parental consent was obtained) and were paid for their participation.

Participants all spoke Swiss-German as their first language, Standard High German as their first L2, English and French as their second L2s, and crucially, they had no knowledge of Chinese. Participants were also asked to self-assess their listening, writing and reading capacity in all languages and dialects known, using the Common European Framework of Reference for Languages (CEFR; Council of Europe 2011). People who worked with language in their daily lives and/or who considered themselves to be language experts were not included in the study.

3.2 Materials

The experiment had two sets of stimuli. First, we exposed participants to an audio-visual sample of real Mandarin Chinese in the form of a fully controlled seven-minute weather report (see Fig. 1). The report consisted of 120 clauses of Mandarin Chinese based on 292 different words (types) whose frequency (number of tokens) and distribution in the report, as well as tone, was controlled for, accompanied by 6 weather charts illustrating the content in different regions of an imaginary country. The weather report was spoken by a female native speaker.

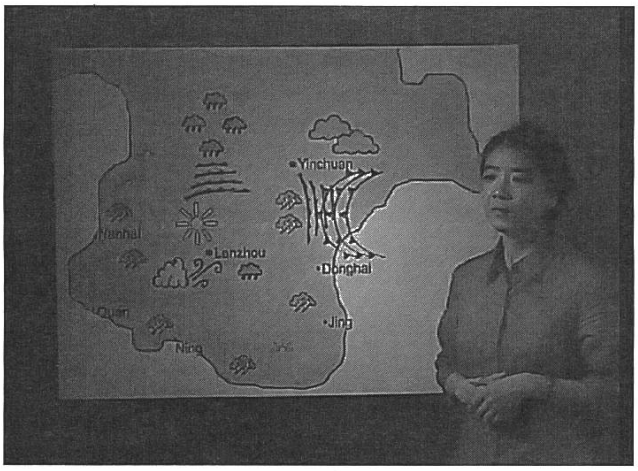

Figure 1: Chinese weather report extract.

Second, we tested participants using a lexical decision task. The stimuli of the lexical decision task consisted of 256 monosyllables, half of which were real Chinese words serving as filler syllables, and half of which were Chinese non-words containing phonotactic violations of four different types illustrated in Figure 2. Non-words with two- and three-consonant clusters word-finally were

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2 In the range from 10 to 20 years, we decided to select participants aged 10-12 and 15-16, respectively.

used as control syllables to ensure that participants stayed on task. These structures are possible in the participants' native language, but impossible in Chinese. We assumed they would be easy to reject as being Chinese since they sound "Germanic". Non-words of a CVC-structure constituted the critical experimental syllables. They were further divided into syllables that illegally ended in a nasal (CV_nasal) or a plosive (CV_plosive). The CVC structure per se is possible both in the participants' native language and in Chinese. However, to correctly identify the CVC syllables ending in a nasal or a plosive as not being Chinese above chance level requires making use of the input.

Syllable Type	Items	Consonant cluster	Example	Items	Consonant cluster	Example
'Control'	16	V<u>CCC</u>	*alst*	16	V<u>CC</u>	*ans*
'Critical'	16	CV<u>C</u> (illegal nasal)	*gam*	16	CV<u>C</u> (illegal plosive)	*mat*

Figure 2: The four different syllable types (non-words) in the lexical decision task. The illegal consonant clusters or consonants are underlined.

3.3 Procedure

Participants were seated in front of a laptop computer-screen and were instructed to *"just sit and watch this short movie"* without any further instruction to promote implicit learning. Immediately after the video, participants were asked to perform the lexical decision task, using a Cedrus button-box (Model RB-834) and headphones (MBK C 800).

Throughout the experiment, participants listened to words in headphones. In the written instructions to the lexical decision task they were asked to decide whether a presented word was Chinese or not by pressing either the right button for "Chinese" or the left button for "not Chinese". A left-handed version was constructed to rule out possible effects on reaction times by handedness. The experiment was programmed using E-Prime 2.0 (Release Candidate 2.0.8.90).

3.4 Data treatment and analyses

The results from the lexical decision task were coded for accuracy. Accuracy was coded with '1' for hits and correct rejections, and '0' for false alarms and misses. For the analyses, accuracy was first transformed into proportions and then transformed into arcsine-square-root values for the purposes of statistical analysis (t-tests and analysis of covariance, ANCOVA). Age was treated as a continuous variable.

4. Results

We first computed mean accuracy scores per syllable type across all participants and ages. Figure 3 summarises the untransformed mean proportions of correct rejections.

Consonant cluster	Mean accuracy (SD)	Consonant cluster	Mean accuracy (SD)
VCCC	0.895 (0.171)	VCC	0.777 (0.205)
CVC (illegal nasal)	0.496 (0.227)	CVC (illegal plosive)	0.750 (0.195)

Figure 3: Mean (untransformed) proportion of correct responses on the lexical decision task per syllable type.

Next, we examined whether the mean response accuracies differed significantly from chance (= .50 in proportions, but = .79 in arcsine-square-root). Right-tailed Student's t-tests revealed that the accuracy scores for three of the syllable types were significantly different from chance (VCCC t=24.995, df=151, p<.001; VCC t=14.924, df=151, p<.001; and CV_plosive t=14.357, df=151, p<.001). In contrast, responses to CV_nasal syllables were at chance (t=-0.018, df=151, p>.05). The results suggest that participants overall were able to correctly reject the consonant-cluster syllables as not being Chinese, and that they were also able to identify the CV_plosives as not being Chinese. As a group, they were guessing on the CV_nasal syllables.

We then examined whether participants' age and the syllable type affected response accuracy on the lexical decision task. An ANCOVA with age as the covariate revealed a main effect of Syllable Type (F=61.201, df=3, p<.001), a main effect of Age (F=17.08, df=1, p<.001), and critically, an interaction between Age and Syllable Type (F=3.68, df=3, p<.05). In other words, the response accuracy to different syllable types varied across the life span.

In a next step, we investigated this interaction further. Because we treated age as a continuous variable in this study, we examined possible correlations between the mean accuracy scores per syllable type and age using a Pearson Correlation. Figure 4 summarises the findings. For each syllable type (except for CV_nasal) there was a significant correlation between higher accuracy and increasing age. Responses to phonotactically illegal syllables with three-consonant clusters in the offset (VCCC) were relatively easy to reject at all ages. These were the control syllables that were supposed to be easiest to reject as non-words. However, they became significantly easier to reject with increasing age (r=0.30, p<0.001). As predicted, responses to phonotactically illegal syllables with two-consonant clusters in the offset (VCC) were somewhat more difficult to reject than VCCC-syllables. But they also became significantly easier to reject with increasing age (r=0.22, p<0.01). Critically, however, responses to illegal CVC_plosive syllables also correlated significantly with increasing age, albeit less strongly so (r=0.17, p<0.05). This suggests that participants did derive phonotactic knowledge from the input, since this structure is possible in the participants' native language but not in the target language. The decision to reject these syllables must therefore be based on knowledge created from the input. The illegal CV_nasal syllables, however, were more difficult to identify. There is no significant correlation with age for responses to CV_nasal syllables, suggesting that the identification of these syllables was not influenced by age. In sum, the overall performance on the lexical decision task improved with increasing age or remained stable across the life span.

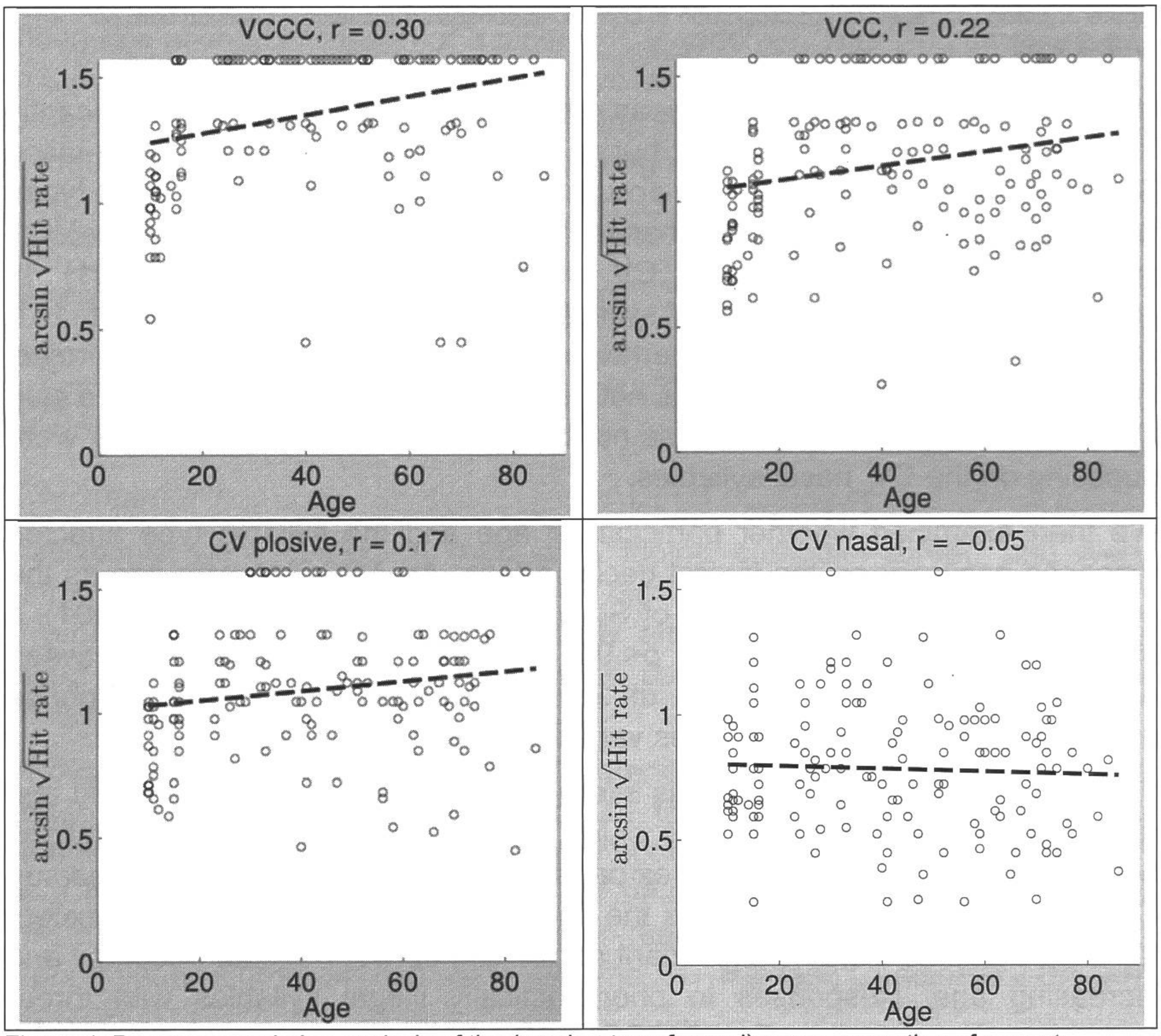

Figure 4: Pearson correlation analysis of the (arcsine-transformed) mean proportion of correct answers per syllable type (VCCC, VCC, CV_plosive, CV_nasal) across all subjects and ages.

5. Discussion

This study explored how quickly learners can learn to distinguish sound regularities in an unknown, natural language that has not been pedagogically simplified for them, and whether they can generalize knowledge that they acquired from the input to new stimuli. Moreover, we tested whether this capacity changed across the life span. We found that participants were able to generalize newly acquired phonotactic knowledge in order to correctly reject non-words in the unknown language after only seven minutes of input. We also found that this capacity improves or at least remains stable across the life span.

There is no evidence for a declining capacity to learn and generalise L2 phonotactics across the age span.

These results are consistent with accumulating evidence for an adult capacity to swiftly learn to process complex natural language material from novel L2 input. Our results support findings both in the artificial and statistical language learning literature (Saffran *et al.* 1996; Saffran *et al.* 1997; Friederici *et al.* 2002; Perruchet & Poulin-Charronnat 2012) and in studies on first exposure to natural language (Rast 2008; Gullberg *et al.* 2010; Veroude *et al.* 2010; Gullberg *et al.* 2012; Shoemaker & Rast 2013), suggesting a powerful human ability to implicitly acquire and generalize abstract information after minimal contact with a new language. In particular, this study highlights the capacity for doing this in a context of complex, continuous natural input, which has not been simplified for the benefit of the learner. What is more, contrary to popular belief and to the literature dealing with age effects in acquisition, this ability seems to improve or at least remain stable across the life span.

DeKeyser (2003, 2012, 2013) holds that only children learn implicitly and that adults learn explicitly and lose the ability to learn implicitly "somewhere between childhood and early puberty" (DeKeyser 2003: 335), a "qualitative shift from implicit to explicit" (DeKeyser 2012: 456). According to DeKeyser, there is "little hard [empirical] evidence of learning without awareness" in general (DeKeyser 2003: 317) and especially for the implicit learning of abstract structures by adults (DeKeyser 2003: 321). Our results clearly speak against DeKeyser's claim that adults are no longer capable of implicit learning, since we observe an increase in the ability beyond the ages of early puberty (work presented by Krakenberger 2014 this issue) also showed elderly to be eager learners of foreign languages, as well as results in the written modality of work presented by Berthele & Vanhove 2014 this issue). However, it is important to specify that what significantly improved with age in our study was the ability to reject L1-sounding three- and two-consonant clusters as being Chinese. The ability to correctly detect CVC-non-words only partly improved with age. That is, it depended on the exact phonemes of the CVC syllable. Importantly, however, that ability also did not *decline*, but remained constant across the age span. The explanation for these findings may be found in aspects of higher crystallized intelligence or stored information, such as general knowledge, vocabulary and learned skills (compare Cattel 1987). This again might be related to more or less L1-influence on L2-processing, but that remains to be studied further. At any rate, these findings still offer a challenge to a traditional critical or sensitive period account of the perception and generalization of newly acquired phonotactic knowledge to non-native language input.

The results from the current study, therefore, are not in line with findings from proponents of an early age of onset (AO) advantage (e.g. Abrahamson & Hyltenstam 2009). It is possible that age effects are more visible in production, typically examined in studies of ultimate attainment and nativelikeness, than in comprehension and perception studies. Our results suggest a constant or even increasing capacity along the life span to *perceive* and *generalize* newly acquired phonotactic knowledge. It remains an important challenge for future research to examine the potential relationship between production and comprehension and possible differing age effects on nativelikeness across these domains.

A caveat, however, is that 'nativelikeness' itself is not an unproblematic notion when considering speakers with varying and multilingual language experiences. A monolingual is not comparable to a bi- or multilingual. There is now plenty of psycholinguistic evidence to suggest that a bi- or multilingual brain simultaneously uses the L1 and the L2(s) while processing any foreign language - a task that entails additional executive control- and subcortical processes and that is therefore hardly comparable to processing only one language (e.g. Friederici *et al.* 2002; Grosjean 1989; Herdina & Jessner 2002; Abutalebi 2008; Abutalebi & Green 2007; Kroll 2008). Usage-based approaches to language acquisition (e.g. Ellis 2006; Ortega 2013) also hold that "an individual's creative linguistic competence emerges from the collaboration of the memories of all the utterances in their entire history of language use and from the frequency-biased abstraction of regularities within them." (Ellis 2006: 2). This in turn means that multilingual experiences will affect the whole system, making a monolingual native standard highly problematic. Such a view has potential practical implications, for example for instructed language learning and teaching. DeKeyser (2003) suggested that teaching methods should be adapted to the circumstances instead of blindly setting the learner's age of onset to as early as possible, since conditions for implicit learning often cannot be provided by schools, because "[...] time is limited and learning highly structured [...]" (DeKeyser 2003: 335, 336). In a related vein, Muñoz (2011) emphasized that sufficient intensity is needed for implicit learning to take place, both in terms of amount of input and intensive interactions with well-trained teachers and age-appropriate materials. Muñoz (2006) provided some support for the long-standing notion that adult learners have an advantage at the initial rate of learning, while child learners have an advantage at implicit learning (compare Krashen *et al.* 1979). Yet, she specified that child learners would *not* outperform adults in the long run if similar exposure and instruction conditions were provided, since young learners need much more input in order to learn implicitly. Nikolov & Mihaljevic-Djigunovic (2011) have similarly pointed out how complex the relationships are between the (early) language learning capacity and the development of cognitive and affective skills, and how these interactions can give us insight into the multi-competence (cf. Cook 1992) that emerges from the very beginning of foreign language learning. The current study has highlighted how remarkably *little* experience can make a difference allowing for highly abstract types of knowledge to emerge.

In conclusion, the present study has allowed us to investigate the human capacity to quickly acquire and generalize new abstract knowledge about an unknown language. Overall, our results suggest a powerful human mechanism for detecting regularities in messy and complex natural language input, a capacity that seems to benefit from more experience along the life span.

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