Learner Differences in Metalinguistic Awareness: Exploring the Influence of Cognitive Abilities and Language Experience

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1. Introduction

Recent emergentist views of language propose that its structure is "fundamentally molded by preexisting cognitive abilities, processing idiosyncrasies, and limitations" (Beckner et al., 2009, p. 17). Thus, the psychological characteristics that distinguish us as human contribute to language change at the collective and individual levels. With regard to the latter, it is particularly important for second language professionals to understand the nature of learners' individual differences (IDs), so that we may appreciate these abilities, adapt instruction to idiosyncrasies, and circumvent limitations to the greatest extent possible. The outlook for research on IDs extends this perspective. For example, Dörnyei (2009) views IDs in second language (L2) research as multi-componential, integrated, dynamic, interacting, and complex. These themes are touched on throughout the following paper, which examines the role of L2 aptitude, working memory, and language experience in metalinguistic awareness stemming from exposure to an artificial language.

2. Demystifying awareness for L2 research

Following Schmidt (1990 and elsewhere), awareness is a form of consciousness implicated in mental processes that are crucial to L2 learning, including perception, noticing, and understanding. Regarding the distinction between noticing and understanding, he wrote:

> Noticing is related to rehearsal within working memory and the transfer of information to long-term memory, to intake, and to item learning. Understanding is related to the organization of material in long-term memory, to restructuring, and to system learning. (Schmidt, 1993, p. 213)

Second language acquisition relies on both item and system learning. Schmidt thus aptly characterized L2 development in terms of the synergy between awareness at the level of noticing and at the level of understanding. He has argued that while noticing is a necessary and sufficient precondition for learning, understanding, which includes metalinguistic awareness, is facilitative, though not required (Schmidt, 1990, 2001, 2012). While this distinction between noticing and understanding has not gone unchallenged by theorists (e.g., Truscott & Sharwood Smith, 2011), Schmidt's noticing hypothesis, as well as later formulations proposed by Robinson (1995a, 2003), remains at the core of much empirical work on L2 learning. At the same time, the exact nature of the relationship between noticing, awareness, and learning is a matter of some debate.[1] In fact, research on awareness in L2 learning has

[*] This research was supported by grants from the Elizabeth Carr-Holmes Scholarship Fund and the Bilinski Educational Foundation. I am grateful to Sunhee Kim, Paul Meara, Luca Onnis, and Hannah Rosenberg-Jones for their assistance and also to Richard Schmidt, Gisela Granena, and two anonymous reviewers for comments.

[1] For example, implicit learning, or learning without awareness, has been empirically demonstrated in some studies, most notably by Williams (2005). However, other studies have failed to replicate these results (Hama & Leow, 2010; Faretta-Stutenberg & Morgan-Short, 2011).

often focused not on noticing per se, but on subsequent understanding of patterns, rules, or form-meaning mappings.

Empirical studies on the issue of awareness have generated findings in support of these distinctions and their importance for second language acquisition. For instance, studies by Leow and colleagues have produced evidence for: (a) various levels of awareness and their effects on the recognition and production of Spanish morphology (Leow, 1997); (b) superior performance by aware versus unaware learners (Leow, 2000); (c) the impact of task conditions, instructions, and subsequent awareness on Spanish syntax (Rosa & O'Neill 1999); and (d) stronger effects of self-reported understanding versus noticing on posttest and delayed posttest measures (Rosa & Leow, 2004). The practical implications for L2 learning in classrooms are transparent in this line of research.

Other recent reviews of the role of awareness in L2 learning have highlighted a variety of methodological considerations. For instance, concurrent and retrospective measures of awareness entail rather distinct consequences, as discussed in Leow and Bowles (2005) and Bowles (2010). The sensitivity of measures to awareness (Robinson, 2007a) and combined use of subjective and objective tests of learning are also of particular interest (Robinson, Mackey, Gass, & Schmidt, 2012). Finally, researchers have stressed the need to consider not only multiple levels of awareness (e.g., noticing, reporting, and understanding), but within these levels, additional classifications, such as full and partial reports of grammatical rules (Leow, Johnson, & Záráte-Sandez, 2011).

According to Jessner's (2006) detailed account, metalinguistic awareness has a long history in research on language learning and use and, owing to researchers' differing orientations, terminology within this area has been not been consistent. However, in line with Jessner, this paper adopts the term *metalinguistic awareness* to refer to "what learners know about language through reflection on and manipulation of language" (2006, p. 43). This is taken to be a result of awareness at the level of understanding. Based on awareness at the level of understanding, and engagement with reflective processes, learners arrive at what Koda (2007) labels an "explicit representation" (p. 13) of underlying linguistic structure, which can be broken down into facets including syntactic, phonological, and morphological awareness. The study presented in this paper relates to metalinguistic awareness in this restricted sense.

The present study utilized artificial language input as the basis for investigating language learners' metalinguistic awareness. While the extent to which artificial language studies can be compared to language learning in instructed or naturalistic settings is limited, there are several advantages to this approach. Among others benefits, the use of artificial languages enables L2 researchers to examine learning under conditions where the amount and type of exposure are identical across participants (see, e.g., Ellis & Schmidt, 1998; Hulstijn, 1997; Yang & Givón, 1997). Of particular importance to the current study, it can be assumed that learners had no previous knowledge of the artificial language they were asked to describe.

3. Learner factors and awareness

Previous research has established connections between individual differences, on the one hand, and awareness in the sense of noticing and understanding, on the other. Among studies that have examined noticing, Mackey, Philp, Egi, Fujii, and Tatsumi (2002) uncovered a relationship between working memory capacity and noticing of L2 interactional feedback. Philp (2003) offered evidence that developmental level, recast length, and the number of changes within recasts influence noticing (defined as accurate recall of recasts). More recently, Park (2011) revealed distinct patterns of noticing by Japanese and English L1 learner groups with zero versus some knowledge of Korean. Links between individual difference measures and awareness at the level of understanding have also been described. Regarding aptitude and awareness, Robinson (1995b, 1997a) reported greater ability to verbalize syntactic rules in an implicit training condition among ESL learners who scored higher on subsections of the Modern Language Aptitude Test involving grammatical sensitivity (i.e., Words in Sentences). Bell (2009) also found that inductive language learning ability, as measured by the Pimsleur Language Aptitude Battery, predicted awareness of French grammatical gender while Anglophone learners completed a crossword puzzle. However, although noticing (and hence, understanding) is driven primarily by learner-internal factors (Schmidt, 1990, 2001; Schmidt & Frota, 1986), relatively few studies have attempted to describe noticing and/or metalinguistic awareness by groups of learners possessing different aptitude, working memory ability, and linguistic backgrounds. Thus, building on these prior investigations of the impact of learner factors on L2 awareness, and theoretical proposals emphasizing the multicomponential nature of IDs (described in the next section), the following constructs were incorporated into the present study.

3.1. Aptitude

Under the traditional view, L2 aptitude controls the rate at which a person is able to learn a second language, and consists of: (a) phonemic coding ability, (b) grammatical sensitivity, (c) memory abilities, and (d) inductive language learning abilities (Carroll, 1981, 1990; see Dörnyei, 2005; Skehan, 1998 for discussion). However, there are a number of newer perspectives, consistent with Dörnyei's (2009) call for research that unveils the multi-componential, integrated, dynamic, interacting, and complex nature of learner differences. First, Skehan (2002, see also Dörnyei & Skehan, 2003) has described aptitude components defined in terms of the distinct psycholinguistic processes recruited during different stages of second language acquisition, including noticing, pattern identification, and pattern manipulation. Second, Robinson (2002, 2005, 2007b) has built on the work of Snow (1994) in his aptitude complex/ability differentiation model, which argues that sets of primary cognitive abilities contribute to ability factors, which then form the basis of aptitude complexes influencing L2 learning in instructed settings. Third, Schmidt (2012) has pointed out links between aptitude, focal attention (i.e., noticing), and learning, suggesting, as well, that learners' histories of linguistic experience may shape cognition at the level of noticing.

Alongside these theoretical developments, the recent availability of computerized measures of second language aptitude has supported research to broaden our understanding of its role in multiple L2 phenomena. In particular, the LLAMA aptitude tests developed by Paul Meara (2005), or previous versions, have been used in recent studies on near-native ability (Abrahamsson & Hyltenstam, 2008) and explicit versus implicit learning ability (Granena, 2012), among other areas. The full version of the LLAMA test presents four learning tasks based on input which is presumably independent of test-takers' L1: vocabulary learning, sound recognition, sound-symbol correspondence, and grammatical inferencing, or inductive learning of form-meaning mappings.

The grammatical inferencing subtest (LLAMA F) is of particular interest. Because the aptitude component it measures is not directly assessed by the Modern Language Aptitude Test (MLAT; see Dornyei, 2005, p. 40), this ability is arguably less well researched than other dimensions of aptitude. The subtest takes advantage of the computer-based format through an interactive training phase presenting a set of images described in an artificial language. Thus, it simulates L2 learning by engaging test takers in the discovery of form-meaning associations. In this way, it highlights abilities that are assumed to be important in task-based language teaching (see Doughty & Long, 2003) and other contemporary approaches to language instruction, which do not rely solely on deductive learning.

3.2. Working memory (WM)

Simply put, WM is "information temporarily held accessible in the mind" (Cowan, 2008, p. 1015). In the wider cognitive psychology literature, working memory capacity (WMC) has long been discussed in terms of its intricate connection to language acquisition (e.g., Baddeley, Gathercole, & Papagno, 1998), language comprehension (Daneman & Carpenter, 1980; Daneman & Merikle, 1996), and attention (Cowan, 1995). As a result, the construct of WMC has generated substantial interest in second language studies (see Ellis, 2001, 2005; Juffs & Harrington, 2011; Robinson, 2003; Wood Bowden, Sanz, & Stafford, 2007; Wen, 2012; Williams, 2012, for reviews). In their review of L2 studies on WM, Watanabe and Bergsleithner (2006) offered a synthesis of 20 empirical reports published between 1974 and 2006, taking account of: (a) domains of application, (b) measures used, (c) scoring procedures, (d) test reliability, and (e) relation to L1 WM. The synthesis revealed a broad range of L2 applications as well as a variety of WM measures. However, it was also found that the reliability of measures used to assess WM was reported in only 5 of the 20 studies reviewed.

In terms of its relationship to other constructs, there is theoretical consensus among cognitive psychologists (Miyake & Friedman, 2002), second language acquisition researchers (Doughty et al., 2010), and testing specialists (Stansfield & Winke, 2008) that WM is an essential component of L2 aptitude, as well as empirical work to support this connection. For example, Yoshimura (2000) provided evidence for a relationship, in the form of significant correlations between reading span tests and the Word Associates and Language Analysis subtests of the Language Aptitude Battery for Japanese, which is based on the MLAT. These correlations ranged from $r = 0.47$ to 0.51. Other studies have shown that WM and aptitude predict L2 proficiency (Hummel, 2009; see also Linck & Weiss, 2011).

Lastly, a recent narrative review by Juffs and Harrington (2011) discussed the potential association between WMC and attention, in terms of measures "that involve maintenance of immediate attention and resistance to distraction and that are sensitive at the millisecond level" (p. 160). Though such processes do appear likely to support the ability to learn second languages over a short time span, L2 studies have tended to employ complex span measures, such as reading or listening span. Nonetheless, more dynamic measures, including the *n*-back task, which is distinct from span measures in that it requires continuous maintenance, monitoring and updating of stimuli, along with speeded responses, may contribute to understanding connections between SLA processes, WM, and attention (for further discussion of the *n*-back task, see Edelman, 2008; Conway et al., 2005; Kane, Conway, Miura, & Colflesh, 2007).

3.3. Language experience

The role of language experience, or language background, in subsequent language learning is complex.[2] Important work by Jessner (1999, 2006) has drawn attention to the relationship between multilingual language experience and metalinguistic awareness. For instance, she has emphasized: (a) the role of learners' "willingness to activate prior language knowledge" (1999, p. 206), (b) the dynamic nature of their multilingual competence, and (c) the overall distinctive nature of third language learning. There appear to be at least two approaches to investigating the relationship between metalinguistic ability and language experience. One examines the relationship between previous language study and *accumulated metalinguistic knowledge* in an additional target language. The other investigates the connection between previous language study and *emergent metalinguistic awareness* of meaningful artificial language input under experimental conditions. As an example of the first, Roehr and Gánem-Gutiérrez (2009) conducted a study with L2 learners of either German or Spanish. To assess metalinguistic knowledge, they used a two-section test in which learners corrected written errors and then identified grammatical functions, in their target language. Results showed cumulative years of study of *other* L2s to be the strongest predictor of L2 metalinguistic knowledge. Martin and Ellis (2012) is an example of the second approach. These authors conducted a study on IDs in artificial language learning, employing a questionnaire methodology in which participants were asked to describe the language studied. Martin and Ellis observed that years of foreign language experience (i.e., years spent studying foreign languages) did not account for explicit knowledge of a plural rule, although scores from a vocabulary measure did. Among other differences, the former study examined metalinguistic knowledge that had been accumulated over an extended period of L2 study, while the latter focused on its emergence under experimental conditions, using novel language input. It is therefore not surprising that the results of these two studies differed. More work, building on both of these approaches, would presumably shed light on connections between language experience and learners' ability to generate and use explicit representations of language structure.

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[2] Researchers have defined language background or experience in various ways, including: (a) years of study (e.g., Roehr & Gánem-Gutiérrez, 2009), (b) knowledge of certain types of languages (e.g., Williams & Lovatt, 2003), (c) total number of languages known (e.g., Grigorenko, Sternberg, & Ehrman, 2000), and (d) self-ratings of language proficiency (e.g., Kempe, Brooks, & Kharkhurin, 2010).

Also relevant to this discussion is the issue of whether linguistic experience enhances language aptitude. For instance, Grigorenko, Sternberg, and Ehrman (2000) addressed the role of language learning experience in aptitude, linking the number of languages used by participants to better performance on the CANAL-F aptitude test. Abrahamsson and Hyltenstam (2008) argued that aptitude and language experience are related, describing the high aptitude learners in their study as exhibiting a strong devotion to language. Furthermore, there is also some evidence for a link between language background and phonological short-term memory (see Williams & Lovatt, 2003, Experiment 1). Such efforts notwithstanding, it appears that Sawyer and Ranta's (2001) assessment—that research had not determined "which aspects of aptitude are susceptible to what sorts of experience" (p. 334)—remains accurate to this day. Jessner (2006, pp. 64–69) concludes her review of the research on language aptitude and metalinguistic ability by noting that it is difficult to tease apart their separate contributions to learning; however, it seems at least possible that the abilities ascribed to speakers of more than one language may aid them in applying their aptitude (regardless of whether such aptitude is immutable or enhanced though additional language learning) in specific learning contexts.

Finally, in addition, we might expect bilingual or multilingual experience to correlate with some of the primary cognitive abilities that Robinson (2007b) argues comprise aptitude within a multicomponential, interactionist framework. These include, for instance, perceptual speed and pattern recognition as determinants of learners' ability to notice gaps. Support for this conjecture comes from the literature on bilingualism and cognition. For instance, bilinguals perform better than monolinguals on cognitive tasks such as the Simon task and the Stroop task (Bialystok, 2009; Bialystok & Craik, 2010). These experimental tasks of executive control involve updating, shifting, and inhibiting attention in response to stimuli (Miyake, Emerson, Witzki, & Howerter, 2000, see also Lu & Proctor, 1995). Related to this, a recent meta-analysis found large effects for bilingualism on attentional control, as well as effects on a number of other cognitive variables (Adesope, Lavin, Thompson, & Ungerleider, 2010).

Based on the preceding review, an exploratory study was designed to examine the following research questions:

1. What is the relationship between aptitude, working memory, language experience, and subsequent metalinguistic awareness?
2. What qualitative differences in awareness are associated with different learner abilities?
3. Which combination of variables appears to predict metalinguistic awareness of a novel language among participants?

4. Methods

4.1. Participants

The following report is based on data from 27 volunteer participants. These participants ranged in age from 18 to 28 ($M = 22.67$; $SD = 2.90$). Table 1 provides further characteristics of the participants.

Table 1. *Participant characteristics (*N *= 27)*

Characteristic	*n*	%
Gender		
Female	15	56
Male	12	44
Institutional status		
Graduate	6	22
Undergraduate	18	67
Other	3	11
Major		
Language-related	14	52
Non-language-related	9	33
Undeclared	4	15

The language background questionnaire confirmed that participants had learned from one to six languages in addition to English, their dominant language, prior to the study (*M* = 3.37; *SD* = 1.36). Participants reported having learned the following languages, listed here alphabetically, with language names as given by participants: Arabic, Bahasa Indonesia, Chinese, Chuukese, French, German, Hawaiian, Hebrew, Italian, Japanese, Korean, Latin, Lingala, Mandarin, Marshallese, Mortlockese, Pidgin, Portuguese, Russian, Spanish, Tagalog, Taiwanese, Teochew (Chinese), Vietnamese, and Xhosa.

Those who joined the study visited the laboratory and received a brief overview prior to signing a consent form approved by the university's Human Studies Program. They then completed the tasks described below in the following order: (a) LLAMA F training phase, (b) LLAMA F test phase, (c) awareness questionnaire (based on LLAMA F input), (d) reading span task, (e) dual 3-back task, and (f) language experience questionnaire. Upon completion, they were paid $7 and signed a form to indicate receipt of payment.

4.2. Materials and procedures

4.2.1. Aptitude, WM and experience measures

The following independent variable measures were used.

4.2.1.1. LLAMA F

The LLAMA F test of grammatical inferencing (Meara, 2005) is a computer-based test that presents an artificial language consisting of written statements describing pictures. For example, one item displays the sentence *unak-ek eked-ilad* with a computer image of two green square characters depicted so that they appear to be walking under an object. Although the input is ambiguous (insofar as the meaning of all elements cannot be stated precisely), the language may be interpreted as having the structure VP-NP, with singular number marking on nouns, and dual or plural marking on verbs. Based on the training phase input, participants are likely to construe the foremost sentence element, *unak,* as an intransitive verb, which is marked for dual number (*-ek*), and *ilad* as denoting square characters, which take the descriptive adjective *eked-* (green) in this example. Furthermore, the spelling of these adjectives follows a morphophonological rule (i.e., the final consonant in color adjectives undergoes a voicing change depending on context) and a voicing rule also governs the choice of singular marker (which can be *sa* or *za*). During the five-minute training phase, participants were instructed to try to learn as much as possible about the language by viewing 20 sample sentences and accompanying pictures.

Following this training phase, participants then completed a two-alternative forced choice task with 20 items. The correct choices consisted of: (a) seven items displaying input which appeared during the training phase; (b) seven items containing trained input arranged using novel word order, which were permissible according to the training phase input; and (c) six items incorporating new nouns into permissible sequences.[3]

4.2.1.2. Automated reading span task (RSPAN)

A version of the reading span task was utilized to measure participants' verbal WM. Participants were asked to recall a series of letters appearing between sentences that they read and judged for plausibility. This study used an automated version of the task (Unsworth, Heitz, Schrock, & Engle, 2005). The measure employed 15 items, with each item consisting of a set of three to seven sentences. Scoring was carried out by the partial-credit, unit-scoring procedure recommended in Conway et al. (2005). That is, the mean proportion of correctly recalled letters within each item was taken as a

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[3] Due to limitations inherent to this study, reliability indices could not be calculated for this administration of the LLAMA F test. For further information on the reliability of the LLAMA tests, interested readers should consult Granena (2012).

measure of WM ability. This task and the *n*-back task described below both included a practice session before the actual test trials. Adopting procedures described by Unsworth et al. (2005, p. 501), Cronbach's alpha was found to be .70, which is comparable to reliabilities reported elsewhere for the RSPAN (Conway et al., 2005; Sanchez et al., 2010).[4]

4.2.1.3. Dual 3-back task

Because the reading span measure relied solely on verbal stimuli, this measure was adopted as a test of participants' speeded recognition of visuospatial information. To create stimuli, the researcher followed guidelines to control for the familiarity (and, thus, verbalizability) of the stimuli (Attneave & Arnoult, 1956). Shapes were presented in one of four quadrants on the screen for 500 ms each. Participants were informed that they should press the spacebar whenever an item matched the one appearing three before it, according to both shape *and* position. 48 trials were used, with 16 (33.3%) targets, and 6 (12.5%) lures. Lures presented an item of either the same shape *or* position at two items back (see Figure 1).

In this visuospatial WM task, participants were instructed to respond only to targets. The primary cues to identifying a target were its shape and position. The specifications above drew on those found in previous studies (e.g., Gray, Chabris, & Braver, 2003, Jaeggi, Buschkuehl, Perrig, & Meier, 2010, see also Jonides et al., 1997). Following Haatveit et al. (2010), in order to assess participants' ability to accurately discriminate target from non-target stimuli on this task, *d'* was computed by subtracting z-scores for the proportion of correct responses (hit rate) from the proportion of incorrect responses (false alarm rate). Based on procedures described in Kane, Conway, Miura, and Colflesh (2007), the internal reliability (Cronbach's alpha) of the target items in the dual 3-back task was .67.

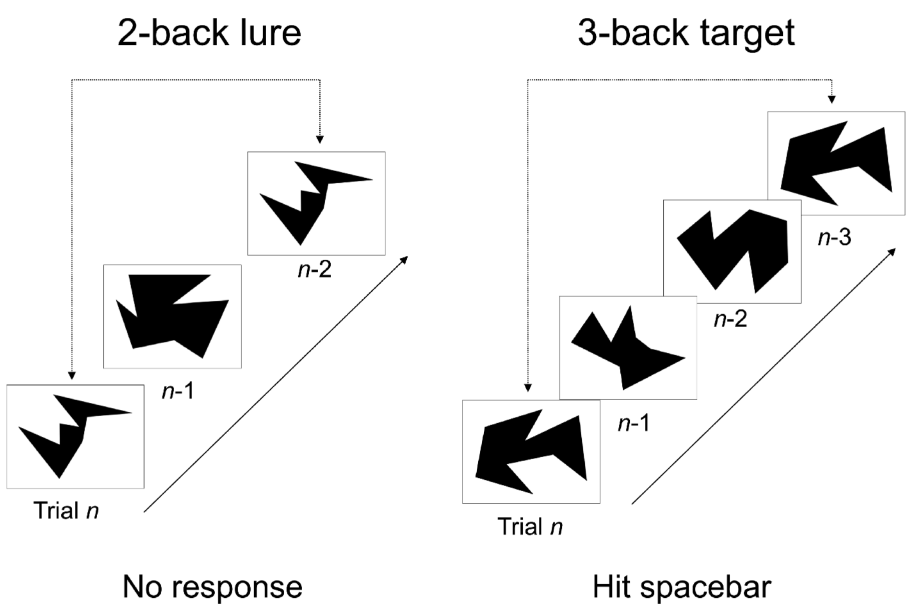

Figure 1. Details of the dual 3-back working memory task.

[4] In their guide to using WM measures, Conway et al. noted that, "estimates of reliability based on internal consistency, such as coefficient alphas and split-half correlations, which reflect the consistency of participants' responses across a test's items at one point in time, are typically in the range of .70–.90 for span scores, where values can range from 0 (*no reliability*) to 1 (*perfect reliability*)" (2005, p. 776).

4.2.1.4. Language experience questionnaire

A published language experience questionnaire (Marian, Blumenfeld, & Kaushanskaya, 2007) was modified and adapted in order to allow a greater number of languages to be entered. A variety of response and question formats were used across the two sections of the instrument, which elicited biodata and information about participants' prior language learning experience. These included fill-in, short-answer, alternative-answer, and Likert-scale questions. All participants completed the survey by typing responses into a Microsoft Word form. For the purpose of this exploratory study, total number of languages and cumulative years of formal language study were each considered separately. In addition, participants were asked to describe their ability in each of the additional languages they reported having competence in, using a 10-point scale adapted from the ACTFL proficiency guidelines (ACTFL, Inc., 2012). They entered separate self-ratings of proficiency in speaking, listening, reading, and writing.

4.2.2. Metalinguistic awareness questionnaire

This written questionnaire was a modified version of one used by Robinson (1995b, 1997a, 1997b). It prompted participants to think about the language and to describe any rules, patterns, or vocabulary they noticed using an open-ended format. The questionnaire was administered immediately after participants completed the LLAMA F test (see Section 4.2.1.1). Coding for metalinguistic awareness was based on accurate reporting of the artificial input. Because participants were instructed to learn as much as possible, without having their attention externally directed toward any specific language features, awareness was assessed according to the number of descriptive levels, or facets (see Koda, 2007) they addressed in their comments. That is, they received one point each for at least one correct statement about syntax, verb morphology, noun morphology, phonology, and lexis, resulting in an awareness score ranging from zero through five.

This resulted in an ordinal scale that, unlike measures tallying the number instances of noticing an L2 form, sought to address learners' understanding of a wide range of features. The focus is on *how much* of the artificial language each participant understood through reflection, rather than on *how many* instances of a specific form she or he noticed. As above, this relates to metalinguistic awareness derived from understanding or system learning, which is in contrast to item learning. It should be noted that the five levels were chosen based on analysis of the artificial language and pilot data. All facets of metalinguistic awareness noted by learners during the pilot (i.e., syntax, verb morphology, noun morphology, phonology, lexis) were included in the final coding. The greater emphasis on morphology resulted from the design of the language, which Meara notes is "primarily concerned with agreement features" (2005, p. 18). Moreover, the combination of features leading to each participant's scale assignment can be expected to vary. In categorizing participants as more or less metalinguistically aware, we focused on the breadth of learner-generated knowledge, in order to examine individual factors that may support the ability to reflect on a novel language according to its various dimensions.

The following steps were taken to assess the reliability of the coding system. First, two raters independently coded questionnaire responses from seven participants and, based on the outcome, discussed improvements in the scoring system. Second, the raters separately coded responses from 16 participants (approximately 60% of the data), and percentage agreement, in addition to Cohen's kappa, were computed to gauge the level of agreement between raters. This led to 81% perfect agreement (i.e., both raters gave the same exact score). The weighted kappa value, which reflects the distance between each of the two raters' scores along the six-point scale, was 0.95. In the case of disagreements, the first rater's scores were used and this rater also scored the remaining data.

5. Results

This section presents the findings of the study. Table 2 provides descriptive statistics for each of the quantitative measures. Among these, RSPAN and the dual 3-back were skewed, however in no case did the distributions appear to differ significantly from normal.

Table 2. *Descriptive statistics*

	Awareness	LLAMA F	RSPAN	Dual 3-back	Number of languages	Years of study
Mean	2.11	58.15	0.87	1.41	3.37	9.00
Median	2.00	60.00	0.90	1.32	3.00	9.00
Skewness	0.44	0.16	-0.71	0.79	-0.15	0.09
Kurtosis	-0.51	-0.58	-0.64	1.10	-0.67	0.02
Min	0.00	20.00	0.69	0.52	1.00	2.00
Max	5.00	100.00	1.00	3.01	6.00	17.00
Range	5.00	80.00	0.31	2.49	5.00	15.00
SD	1.31	21.12	0.09	0.57	1.36	3.37

5.1. Correlations between IDs and metalinguistic awareness

The first research question concerned the relationship between the ID measures and metalinguistic awareness. In Table 3, Spearman correlations between metalinguistic awareness and the other variables are reported, as well as Pearson product-moment correlations for the interval-scale variables. The criterion used to establish significance for all correlations was set at $p < 0.05$, one-tailed.

Table 3. *Inter-correlations among awareness, aptitude, working memory, and language experience*

Measure	1	2	3	4	5	6
1. Awareness	1.00					
2. LLAMA F	0.18	1.00				
3. RSPAN	0.05	0.39*	1.00			
4. Dual 3-back	0.34*	-0.06	-0.11	1.00		
5. Number of languages	0.24	0.19	0.13	0.02	1.00	
6. Years of study	0.15	0.14	-0.14	-0.04	0.52**	1.00

Note. * = $p < 0.05$; ** = $p < 0.01$ (one-tailed)

As the table indicates, there was a positive, significant correlation between the dual 3-back task and metalinguistic awareness ($r(25) = .34$, $p = .04$). In addition, a smaller positive correlation was found between the number of additional languages known to participants and awareness ($r(25) = .24$, $p = .12$), which did not reach significance. Years of formal study and LLAMA F were also positively correlated with scores on the metalinguistic awareness measure, but only to a small degree.

Regarding correlations amongst the predictor variables, the LLAMA F showed a significant positive relationship with reading span ($r(25) = .39$, $p = .02$), which indicates 15% shared variance between these two measures. Also, number of additional languages and years of formal language study were correlated, although this is to be expected given that participants reported learning multiple languages in formal settings. It is also interesting to note that the dual 3-back task and RSPAN were not closely related, which suggests that these measures correspond to distinct abilities.

5.2. Learner abilities and qualitative differences

The purpose of the second research question was to probe any qualitative differences in metalinguistic awareness that may be related to different levels of ability, defined in terms of the variables investigated here. Based on the results of research question one, two groups of participants, whose responses were above and below the median for the dual 3-back task, were created, and their responses to the awareness questionnaire were examined in closer detail. Table 4 presents the results from 25 participants (two participants were excluded from this analysis as their scores were at the median).

Table 4. *Self-reported awareness of linguistic features in two groups based on dual* 3-*back scores*

Feature	Below median (*n* = 12)	Above median (*n* = 13)
Syntax	2 (17%)	5 (38%)
Phonology	1 (8%)	2 (15%)
Noun marker	9 (75%)	11 (85%)
Verb marker	3 (25%)	5 (38%)
Lexis	7 (58%)	10 (77%)

The table shows that, within each group, most participants reported awareness of noun morphology and lexis, while only a few accurately described syntactic or morphophological rules recoverable from the LLAMA F test input. In addition, for each of the five linguistic features coded, a larger percentage of participants who scored above the median on the dual 3-back task gave accurate reports. The difference between the two groups was largest in the areas of syntax and lexis, where the higher-scoring group showed gains of 21% and 19%, respectively.

Participants varied in how they conveyed their awareness of syntax, which may be due to the ambiguous nature of the input. For instance, one reported that, "under, on, behind go in front of the colors and shapes" while another simply noted down "number, color, type" then labeling this "sentence structure". A third participant remarked in more detail that, "the color would come before the shape" and then added, "if there was more than one creature doing a task *em* or *ek* would come after what they were doing (the verb)". These were undergraduates who had either not declared a major, or were not in language majors, though two other participants from linguistics backgrounds also provided descriptions of the word order when asked to describe any rules or patterns they noticed. Each of these participants scored above the median on the *n*-back task.

Differences in self-reported awareness in the category of lexis were also observed. In their questionnaire responses, participants in both groups recalled words and noted translations (e.g., "ilad = square"). However, as noted in Table 4, a greater percentage of participants whose *n*-back scores were above the median reported accurate translations. For instance, as mentioned previously, the artificial input contained lexical words for color and shape. The total number of correctly recalled and translated color and shape words was higher in the group that performed better on the visuospatial WM test (23 instances versus 13 instances).

5.3. Multiple predictors of metalinguistic awareness

On the assumption that ID variables interact in complex ways to predict learning outcomes, further analyses based on the language experience questionnaire data were conducted in order to identify additional possible predictors of metalinguistic awareness. Because it is possible that other dimensions of experience apart from total number of languages studied and years of formal study might reveal an association between L2 competence and awareness, correlations were run to assess the relationships between awareness and participants' self-ratings of proficiency for their strongest language in each of the skill areas: listening ($r(25) = .14$, $p = .25$), speaking ($r(25) = .35$, $p = .04$), reading ($r(25) = .26$, $p = .11$), and writing ($r(25) = .31$, $p = .07$). Of these, speaking ability yielded a significant result. However, no association was found between ratings of speaking ability and dual 3-

back ($r(25) = -.9$, $p = .33$). Thus, an ordinal logistic regression was computed to examine the extent to which scores on the 3-back task and self-rated speaking ability predicted metalinguistic awareness. As shown in Table 5, this model suggests an increase in metalinguistic awareness with increasing working memory, as well as a smaller increase attributable to L2 speaking ability (Nagelkerke $R^2 = 0.32$, $p < 0.00$). The model satisfied the proportionality assumption (see Baayen, 2008). Nevertheless, it is important to emphasize that this finding was not hypothesized, and cannot be confirmed without additional, replication studies.

Table 5. *Summary of ordinal logistic regression model predicting metalinguistic awareness*

Variable	Coefficient	*SE*	*OR*	95% CI	Wald statistic	*p*
Dual 3-back	1.66	0.69	5.27	[1.41, 22.54]	2.40	0.01
Speaking rating	0.48	0.21	1.62	[1.10, 2.50]	2.34	0.02

Note. 95% CI = confidence intervals for odds ratios (*OR*)

6. Discussion

The novel finding of this study was that a measure of pattern recognition, the dual 3-back task, correlated with self-reported metalinguistic awareness. However, this preliminary finding can only be confirmed through additional research. The significant positive correlation between WM, as measured by the 3-back task, and awareness, as well as the smaller positive correlations between the number of L2s learned and awareness, suggests, as did Roehr and Gánem-Gutiérrez (2009), that both cognitive and experiential variables underlie metalinguistic awareness, when relying on self-report data. Interestingly, unlike Bell's (2009) study, inductive learning ability, here measured by the LLAMA F aptitude test, was only weakly correlated with awareness scores. Even though both measures depended on knowledge of the artificial language used, the nature of the tasks, which elicited responses using a closed-response format versus open-ended recall of metalinguistic information, was very different. This finding may also highlight the difference between, on the one hand, grammatical inferencing ability, in terms of recognizing instances and distinguishing between permissible and non-permissible sequences, and, on the other, the metalinguistic knowledge learners generate through reflection. Despite these results, it is still plausible that LLAMA F involves a high level of awareness. It is noteworthy that scores on the LLAMA F test significantly correlated with RSPAN, as previous research has demonstrated that RSPAN and other aptitude subtests are related (e.g., Yoshimura, 2000). It is also interesting that neither LLAMA F nor RSPAN correlated well with the dual 3-back task. Kane et al. (2007) reported similar weak correlations between *n*-back and complex span measures, suggesting that the reason lies in the distinctive demands of each task: The former requires speeded recognition while the latter demands serial recall. In the early stages of learning novel linguistic information, online pattern recognition processes may be particularly useful (Dörnyei & Skehan, 2003; Skehan, 2002).

The awareness data also offered a glimpse into how such learner abilities may qualitatively influence L2 learning outcomes. That is, this preliminary investigation showed that more than twice as many participants who scored above the median on the dual 3-back task demonstrated understanding of syntactic patterns in the artificial language input. After being prompted to describe any rules or patterns, participants showed awareness that noun phrases exhibited a fixed order consisting of color-shape. Furthermore, when asked to report lexical items from the training phase, participants whose scores were higher on this task were more likely to provide accurate translations of the meanings of words for color and shape. Considering that the *n*-back has been claimed to involve pattern recognition, one possibility is that the open-ended nature of the awareness questionnaire enabled participants to apply this ability to a range of features in an unconstrained manner when asked to describe the input they had been exposed to in training.

Lastly, the regression analysis showed that indicators of cognitive ability and experience using languages other than one's primary language predicted metalinguistic awareness. This finding is consistent with recent perspectives on the role of individual differences in L2 learning, particularly those which emphasize the multifaceted nature of learner ability. Under these accounts, factors contributing to learning are sensitive to the setting and the task in which it occurs. Although the evidence is limited, and the generalizability of these results is uncertain, based on these findings it can be suggested that distinct combinations of learner variables determine metalinguistic awareness under incidental conditions. The finding that perceived speaking proficiency in an L2 correlated with awareness may relate to Jessner's (1999) comments on learners' natural inclinations to activate prior language knowledge. This tendency may be greater among those who are regular and/or confident users of an L2. At present, there is little research dealing with the topic of a possible relationship between perceived L2 proficiency, WM, and emergent awareness. However, this finding, if replicated with a larger sample, may warrant a reopening of the aptitude-experience debate motivated by the premise that L2 learning ability involves myriad factors, including those related to cognitive processing abilities and to bilingual/multilingual experience.

Clearly, the small number of participants in this study is a limitation. It should also be pointed out that the measure of metalinguistic awareness employed here is unlikely to have revealed all of the knowledge participants gained. Yet another issue involves the group-split analysis used to explore research question two. Problems associated with this approach include the arbitrary nature of the median cutoff point and the exclusion of some participants' data (Roberts & Gibson, 2002). The results of this study must therefore be considered tentative. Nonetheless, it is hoped that this investigation has demonstrated how theoretical and methodological advances in the areas of aptitude and WM might productively be applied to the study of factors involved in the emergence of metalinguistic awareness among adult second language learners.

This study is the first to demonstrate a link between the dual *n*-back task and metalinguistic awareness. Learner-generated metalinguistic awareness plays an important role in adult L2 learning in both instructed and naturalistic settings. Therefore, understanding the abilities related to it is crucial, especially if these are trainable, as has been shown for the dual *n*-back task (Jaeggi, Buschkuehl, Jonides, & Perrig, 2008). It remains to be seen whether the cognitive abilities measured by this task are reflected in other areas of L2 learning and development besides metalinguistic awareness.

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Selected Proceedings of the 2012 Second Language Research Forum: Building Bridges between Disciplines

edited by
Ryan T. Miller, Katherine I. Martin, Chelsea M. Eddington, Ashlie Henery, Nausica Marcos Miguel, Alison M. Tseng, Alba Tuninetti, and Daniel Walter

Cascadilla Proceedings Project   Somerville, MA   2014

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ISBN 978-1-57473-464-5 library binding

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Jackson, Daniel O. 2014. Learner Differences in Metalinguistic Awareness: Exploring the Influence of Cognitive Abilities and Language Experience. In *Selected Proceedings of the 2012 Second Language Research Forum*, ed. Ryan T. Miller et al., 211-226. Somerville, MA: Cascadilla Proceedings Project. www.lingref.com, document #3098.