Individual differences in implicit and explicit language learning: Working memory, learning styles, and personality

Sarah Grey[(1)], Christine Schoetensack[(2)], Kimberley Bell[(3,4)], Padraic Monaghan[(4,5)], and Patrick Rebuschat[(5, 6)]

[(1)] Fordham University, USA; [(2)] University of Edinburgh, UK; [(3)] University of Manchester, UK; [(4)] ESRC International Centre for Language and Communicative Development (LuCID); [(5)] Lancaster University, UK; [(6)] University of Tübingen, Germany

Acknowledgments: Our research was supported by the Economic and Social Research Council, UK (grant ES/L008955/1) and by the LEAD Graduate School and Research Network (grant DFG-GSC1028), a project of the Excellence Initiative of the German Federal and State Governments. We are grateful to Kara Morgan-Short for helpful discussions on related projects.

Corresponding author:

Dr. Sarah Grey, Department of Modern Languages and Literatures, Fordham University, Bronx, NY 10458, Email: sgrey4@fordham.edu.

Abstract

It is known that cognitive individual differences (IDs) and the explicitness of learning conditions influence adult language learning. However, the potential interactions between IDs, the efficacy of more/less explicit learning, and different types of linguistic information are largely unknown. In this study, we tested learning of syntax and grammatical case under two conditions: incidental and explicit rule-provision ("instructed"). We also assessed individuals' phonological working memory, general working memory, personality, and learning styles. There were significant learning effects for word order and case in both learning conditions. For case, but not word order, the instructed group outperformed the incidental group. Regarding IDs, phonological working memory, personality, and learning styles played significant roles in learning, and the impact of these IDs was mediated by learning condition. These results inform the complex relationships among cognitive processes in explicit and incidental language learning across different aspects of language structure, and in relation to IDs.

Words = 150

Keywords: implicit learning; explicit learning; individual differences; working memory; personality; learning styles

1. Introduction

Learning a new language as an adult is a notoriously challenging and highly variable endeavor. Despite decades of empirical research, it is not clear which types of learning conditions, such as more or less explicit, lead to the most optimal learning outcomes (e.g., Spada & Tomita, 2010). Equally as unclear is the impact of inter-individual differences, such as age or working memory, on learning outcomes, and, more problematically, the complex potential interactions between individual differences (IDs) and different types of learning conditions (e.g., Tagarelli, Borges Mota, & Rebuschat, 2015; Tagarelli, Ruiz Hernandez, Vega, & Rebuschat, 2016). One reason for this limited understanding is the failure to determine the processes that result in observed differences in language learning. However, recent research suggests that cognitive capacities are powerful predictors of successful outcomes in adult language (L2) learning (e.g., Linck, Oesthus, Koeth, & Bunting, 2014). In this study, we further clarify how measures of cognitive capacity, as well as additional measures of learning styles and personality, pattern across different learning conditions, and how they relate to different types of linguistic knowledge.

On the one hand, explicit learning conditions – which typically provide a rule or instruction to search for a rule – have been found to lead to superior immediate learning and better language retention (e.g., Spada & Tomita, 2010). Learning under explicit conditions seems to be reliably mediated by working memory (WM) capacity (see Linck, et al., 2014; Tagarelli et al, 2011). On the other hand, implicit or incidental conditions – which provide no rule or instruction to search for rules – can lead to equivalent, and sometimes even better, outcomes than explicit conditions (Arciuli, Torkildsen, Stevens, & Simpson, 2014; Siegelman & Frost, 2015), including for neurocognitive measures of learning and retention (Morgan-Short, Finger, Grey, & Ullman, 2012).

In terms of interactions between learning conditions and ID measures, an increasing number of studies find that WM may not play a strong role in learning under non-explicit (i.e., incidental) conditions (e.g., Tagarelli, et al., 2015 but see Misyak & Christiansen, 2012) though other ID factors could be uniquely influential (e.g., Morgan-Short, Faretta-Stutenberg, Brill-Schuetz, Carpenter, & Wong, 2014). For example, Grey, Williams, and Rebuschat (2015) recently used a semi-artificial language approach to examine learning of different types of language structure: grammatical case-marking and syntactic word order under an incidental condition.[1] In addition, their study tested individual differences in phonological working memory (PWM), personality, and learning styles. There were no effects for PWM, but both personality and learning styles were related to better learning outcomes, particularly for syntactic word order as compared to case-marking.

However, there are several unresolved questions that arise from previous studies of language learning under explicit and incidental conditions and individual differences. First, although the semi-artificial language in Grey et al. (2015) had the benefit of reducing learning demands by using existing words in the participants' first language (L1), thus avoiding the requirement to acquire the vocabulary, the task may have added non-linguistic memory demands because the existing L1 words were artificially affixed (e.g., "Vase-o Larry-ga cat-ga broke that assumed"). It is therefore important to include a measure of WM that also involves executive function besides phonological functioning, so beyond PWM, in order to ascertain the effect of WM generally on adult language learning under less explicit conditions.

PWM underlies the storage and processing of familiar and novel verbal and acoustic information (e.g., Baddeley, 2003) and PWM capacity has been implicated in language grammar learning (e.g., Speciale, Ellis, & Bywater, 2004). WM capacity more

[1] Semi-artificial languages use the lexicon of a natural language, typically the participants' first language, and the grammar of a different language. For example, Rebuschat and Williams (2012) used a language with English words and German syntax.

generally has been extensively implicated in adult language learning, especially for complex WM measures and explicit conditions (e.g., Linck et al., 2014) but the contributions of PWM in particular and WM in general across different learning conditions are unclear. For example, Tagarelli et al. (2015) found effects of WM for learning of word order in an explicit rule-search condition but not under their incidental condition. However, their semi-artificial language may have added non-linguistic memory demands to the task and inflated the influence of WM under the rule-search condition. Additionally, they only tested learning of word order. Grey et al. (2015), who tested both word order and case-marking and PWM for both L1 and L2, found no effects for PWM capacity on learning under an incidental condition. However, Grey et al. (2015) did not have additional measures of WM or a matched explicit condition to help determine the effects of different memory capacities across learning conditions and linguistic structures.

Other potentially important IDs to include are personality and learning styles, both of which are obvious variables to consider when testing language learning under different conditions (Skehan, 1989). In terms of personality, the Extraversion trait has been linked to outcomes in language learning. For example, Dewaele (2005), Dewaele & Furnham (1999), and van Daele, Housen, Pierrard, & Debruyn (2006) report that Extraversion positively correlates with fluency and complexity measures of L2 speech production. Grey et al. (2015) found a negative relationship between Extraversion and incidental language learning. In implicit learning research, Kaufman et al. (2010) found that intuition, Openness to Experience, and impulsivity were positively related to probabilistic sequence learning. In terms of learning styles, these seem to vary systematically as a function of L2 proficiency (e.g., Violand-Sanchez, 1995), though there is little evidence that different training regimes do actually affect performance according to learning styles (Pashler, McDaniel, Rohrer, & Bjork, 2009). Grey et al. (2015) tested effects of styles on language learning and found small effects, but only tested an incidental learning condition. In general, the lack of matched incidental *and* explicit conditions makes it difficult to gauge how personality and learning styles may apply across learning contexts. The current study extends previous research by including (1) both types of learning conditions, (2) a complex WM measure (in addition to PWM), and (3) measures of personality and learning styles.

We used an artificial language learning paradigm to offset the potential non-linguistic memory demands of a semi-artificial language paradigm. The artificial language was inspired by Brocanto2 (e.g., Morgan-Short et al., 2010, 2012, 2014), which has been widely used in behavioral, electrophysiological, and neuroimaging studies to examine the acquisition of multiple aspects of language structure. We adapted the Brocanto2 lexicon to enable the study of learning for word order and case marking (Brocanto2 has grammatical gender marking, but not case marking). Investigations into the learning of syntactic word order, a highly salient linguistic structure, predominate in research on explicit and implicit language learning (e.g., Tagarelli et al., 2015; Rebuschat & Williams, 2012). The effects of learning conditions on less salient grammatical structures – like case, which is typically difficult to learn (e.g., Robinson, 2002; Rogers, Révész & Rebuschat, 2015) – are under-studied and poorly understood. Consequently, there are gaps in our knowledge of the effectiveness of different learning conditions for different linguistic structures. We tested the learning of these two structures (word order and case) under two conditions: an incidental condition similar to Grey et al. (2015) and Tagarelli et al. (2015), and an explicit condition where rules about case-marking were provided to the learner ("instructed" condition). Additionally, we examined PWM, personality and learning styles, similar to Grey et al. (2015), and complex WM, similar to Tagarelli et al. (2015).

Informed by the studies reviewed above, we made the following predictions about learning outcomes for this study. First, we predicted that both incidental and instructed participants would successfully learn the novel word order and case-marking of the artificial language, as measured by performance on a grammaticality judgment task (word order) and a scene-matching task (case). Second, we predicted that the instructed group would outperform the incidental group. For learning and IDs, we predicted that instructed, but not incidental learning, of the two linguistic structures would be related to individuals' WM capacity and PWM. Finally, we expected to find relationships between learning styles, especially those associated with language rules (e.g., deductive/inductive), and learning in both conditions; and for personality we predicted that Extraversion and/or Openness to Experience would be related to learning outcomes.

2. Method

2.1 Participants

Thirty native speakers of English (19 women) participated in this study. When they arrived to participate, they were randomly assigned to either an incidental or instructed learning condition (each *n* = 15). All participants were students at Lancaster University, and the mean age was 21.2 (*SD* = 1.9). Participants received 18 GBP for their time.

2.2. Materials

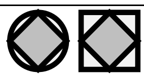
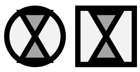
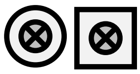
2.2.1. Artificial language

A novel artificial language was developed for this experiment and presented to participants in the context of a computerized board game. The language was adapted from Brocanto2 (Morgan-Short et al., 2010, 2012, 2014). In our adapted version, the lexicon consisted of 11 monosyllabic pseudowords. Nine pseudowords were content words: Four nouns, each of which referred to a game piece, three verbs, and two adjectives which referred to the shape of game pieces, round or square. The language also had two function words that unambiguously marked subjects and objects of sentences. Table 1 displays the lexicon and English translations. All words were recorded in monotone by a male speaker of British

English. The language's grammar has verb-final sentence structure with flexible word order for nouns, which have obligatory subject and object case markers. Thus, word order can either be subject-object-verb (SOV) or object-subject-verb (OSV). Adjectives are optional in the language and, if present, must precede nouns. Since word order is somewhat flexible and since neither nouns, adjectives nor verbs carry inflectional markers, the only linguistic cues to determine subjects and objects are the case markers "li" and "lu".

Table 1

Lexicon of the artificial language

Word	Functional category	English translation	Symbols
plek	noun	plek-piece	
neep	noun	neep-piece	
blom	noun	blom-piece	
vode	noun	vode-piece	
neim	adjective	square	
troise	adjective	round	
praz	verb	switch	
nim	verb	capture	
yab	verb	release	
li	subject marker		
lu	object marker		

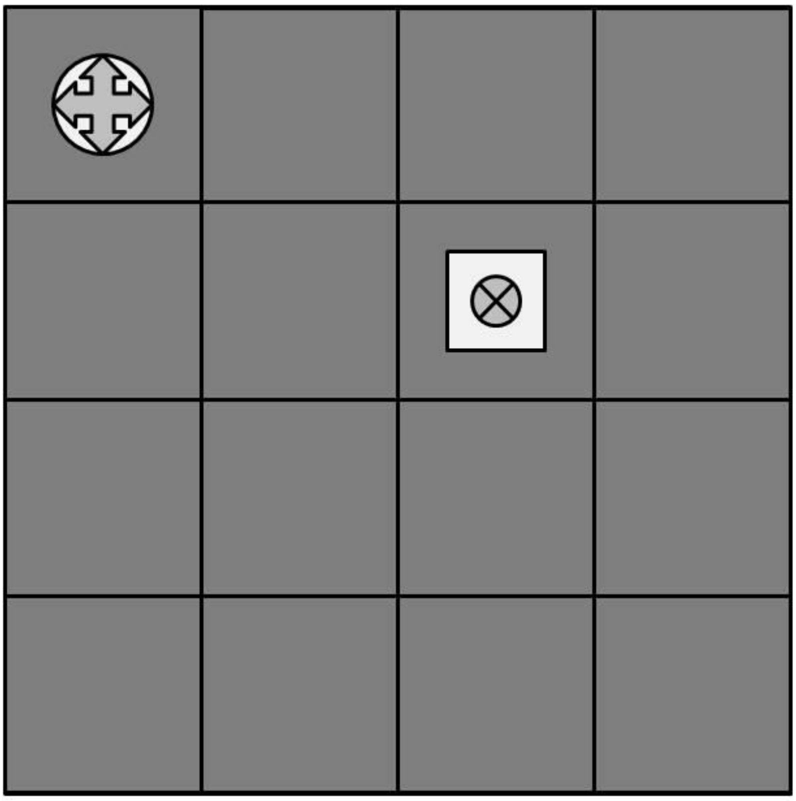


Figure 1. Example of the game board used in the experiment. This specific configuration corresponds to scene 20 from the training set, in which a neep-piece captures a vode-piece. Participants would first observe the scene, then listen to an accurate description (here, “Neep li vode lu nim.”).

Following previous studies on learning of Brocanto2 (e.g., Morgan-Short et al., 2010, 2012, 2014), exposure to this artificial language was situated within the meaningful context of learning to play a computerized board game. An example board and sample configuration are displayed in Figure 1. The rules of the game are independent from the language rules underlying the grammar (i.e., word order and case). A typical trial consists of a game/language “scene”: Participants see a game move involving two pieces and then hear a sentence in the language that describes that move. There were 96 scenes in total, and co-occurrences of nouns, verbs, and adjectives were carefully balanced. Forty-eight scenes were randomly selected for the training set; the remaining scenes were used to construct the testing set.

2.*2.2. Training set*

There were 48 scenes in the training set. Depending on the sentence structure (SOV or OSV) and presence/absence of adjectives, any given scene could be described in six different ways. The testing set therefore consisted of 288 sentences. Half these followed SOV word order and the other half followed OSV. A sentence such as "plek lu_{obj} blom li_{sub} yab" is an OSV item that means "the blom-piece releases the plek-piece."

2.2.3. Testing set

There were also 48 scenes in the testing set. For the *grammaticality judgment task*, which was designed to test learning of word order, twelve scenes were randomly chosen to construct the grammatical items and twelve to construct the ungrammatical items. Each scene was described twice, once with adjectives in both subject and object NPs and once without adjectives. Note that the visual scenes were not displayed in the grammaticality judgment task, i.e. participants were only provided with the auditory descriptions.

For the *scene-matching task*, twelve scenes were randomly selected to accompany matching sentences (auditory descriptions that matched the game move depicted on the screen) while the remaining twelve accompanied mismatching sentences. Whereas the grammaticality judgment task tested participants' learning of word order, this scene-matching task assessed whether participants learned the correct function and use of the case markers. All sentences followed SOV word order. Scene-sentence mismatches could only be correctly identified as mismatches by attending to the case-marking words.

2.2.4. Individual difference measures

We assessed participants' phonological working memory, general working memory, personality, and learning style preferences to examine the influence, if any, of these variables on the learning of word order and case-marking. *Phonological working memory* capacity was measured using Gathercole and Baddeley's (1996) nonword repetition test (NWRT). General *working memory* ability was measured using Unsworth et al.'s (2005) Automated Operation Span Task (AOSPAN). *Personality* was assessed by means of the Big Five personality questionnaire (Costa & McCrae, 1992; McCrae & Costa, 2003). This instrument measures personality in terms of five dimensions or traits: Extraversion, Neuroticism, Openness to Experience, Conscientiousness, and Agreeableness. Finally, *learning style* preferences were measured by two instruments. The Index of Learning Styles (Soloman & Felder, 2005) consists of 44 forced-choice questions which determine respondents' dominant learning styles along four dimensions: active-reflective, sensing-intuitive, visual–verbal, and sequential-global. The Learning Style Survey (Cohen, Oxford, & Chi, 2006) consists of 110 items divided into 11 parts which enable identification of respondents' general learning style by determining the degree to which 23 different characteristics apply to them (see Appendix A).

2.3. Procedure

After providing informed consent, participants completed a short vocabulary pre-training session before being exposed to 288 learning trials. After exposure, participants completed the grammaticality judgment task, followed by the scene-matching task, delivered via E-Prime (Version 2.0). Finally, participants completed the ID tasks.

2.3.1. Vocabulary pre-training.

Participants were informed that they would learn a new game, but first they should learn the names of the game pieces and the names of three moves that these pieces could perform in the game. The two case markers were not part of these training items. Participants learned the names to 100% naming accuracy before continuing to the exposure phase.

2.3.2. Exposure and testing phase

After vocabulary pre-training, participants were informed that they would now play the board game. They were told that they would see 288 game moves followed by an auditory description of the move. Their task was to pay attention to the moves and to the descriptions. Participants in the *instructed* group were given explicit information about the function words "li" and "lu". Specifically, instructed participants were told that the word "li" always indicates the subject/agent of the sentence and the word "lu" the object/patient of the sentence. They were then shown three game moves, which were not repeated later, and asked to identify the agent and patient of the scene and explain which piece would be associated with the subject marker "li" and which piece with the object marker "lu". In the *incidental* group, no information about language structure was provided. The exposure task presented the 288 learning trials in a randomized sequence. After training, participants were informed that the sentences they had heard belonged to a complex artificial language and that we would now test what they learned about the language. Participants in both conditions completed the same tests after exposure.

2.3.3. Grammaticality judgment task

The grammaticality judgment task (GJT) was used to assess whether participants had learned the word order rules of the language. Participants were informed that they would hear 48 novel sentences, only half of which followed the grammar of the artificial language. Their task was to decide as quickly and accurately as possible whether sentences were grammatical or not. In addition to deciding on the grammaticality of the test items, we also asked participants to report the basis of their decision. There were four response categories: Guess, intuition, recollection, and rule knowledge. Participants were instructed to use the *guess* category if (and only if) they have based the judgment on a true guess, i.e. they might as well have flipped a coin. Participants were instructed to use the *intuition* category if their grammaticality decision "felt right", but they could not really say why. Participants were told to use the *recollection* category only if they had based a decision on memory, e.g. a similar sentence or wording that they heard beforehand and still consciously remembered. Finally, participants should pick the *rule knowledge* category if they had based the decision on a conscious rule, i.e. they had to be able to verbally describe the rule at the end of the experiment. These source attributions served as subjective measures of awareness (see Rebuschat, 2013; Timmermans & Cleeremans, 2015, for reviews). Following Dienes and Scott (2005), above-chance performance in grammaticality decisions based on guessing or intuition are taken as evidence for implicit (unconscious) knowledge. On the other hand, above-chance performance in decisions based on recollection or rule knowledge constitutes evidence for explicit (conscious) knowledge.

2.3.4. Scene-matching task

The scene-matching task tested whether participants learned the correct function and use of case markers. Participants were told they would see 48 game moves on the screen and hear a sentence in the artificial language. Their task was to decide whether or not the sentence was an accurate description of the game move ("Does the sentence match the game move?"). Participants were told that, while all sentences were grammatical, only half the sentences were accurate descriptions of the moves. In addition to deciding whether the auditory description matched the scene, participants were again asked to report the basis of their decision (*guess*, *intuition*, *recollection*, *rule knowledge*). As in the previous task, they were reminded to respond as quickly and accurately as possible. They were also reminded of how to select the appropriate source category, e.g. that "guess" had to be reserved for true guesses. As in the previous task, they were asked to respond as quickly and accurately as possible.

4. Results

4.1. Grammaticality judgment task

Shapiro-Wilk tests indicated that the distributions for both groups deviated significantly from normal. Therefore, we used non-parametric tests to analyze the performance of incidental and instructed participants on the GJT. In terms of overall accuracy, the incidental group judged .94 (*Mdn* = .94, *SD* = .04) of trials correctly and the instructed group judged .97 (*Mdn* = .98, *SD* = .04) of trials correctly. Performance was significantly above chance in the incidental group, $p = .038$, and in the instructed group, $p = .015$, indicating that participants had successfully learned the syntax of the artificial language, irrespective of condition. Mann-Whitney U tests with Bonferroni correction confirmed that there were no significant differences between the incidental and instructed learning groups for overall accuracy, $U = 73.50$, $z = -1.67$, $p = .106$, $r = -0.30$. Thus, the provision of explicit rule knowledge to the instructed group provided no advantage for learning word order (see Fig. 2).

We then analyzed accuracy in the GJT based on the four source attribution categories to determine whether participants had acquired implicit or explicit knowledge. The analysis showed that the incidental group performed above chance when basing decisions on guessing, $t(10) = 3.107$, $p = .011$, $d = 1.97$, $r = 0.70$, intuition, $t(13) = 5.322$, $p < .001$, d= 2.95, r = 0.83, recollection, $t(11) = 12.548$, $p < .001$, d= 7.57, r = 0.97, and rule knowledge, $t(14) = 87.571$, $p < .001$, d = 46.81, r = 1.00. The instructed group performed significantly above chance when attributing decisions to intuition, $t(10) = 3.244$, $p = .009$, d = 2.05, r = 0.72, recollection, $t(6) = 5.981$, $p < .001$, d = 4.88, r = 0.93, or rule knowledge, $t(14) = 193.695$, $p < .001$, d = 103.53, r = 1.00. The source attributions thus indicate that participants had acquired both implicit and explicit syntactic knowledge, irrespective of condition

(Rebuschat & Williams, 2012). Table 2 in Appendix B summarizes performance on the grammaticality judgment task across the source attribution categories.

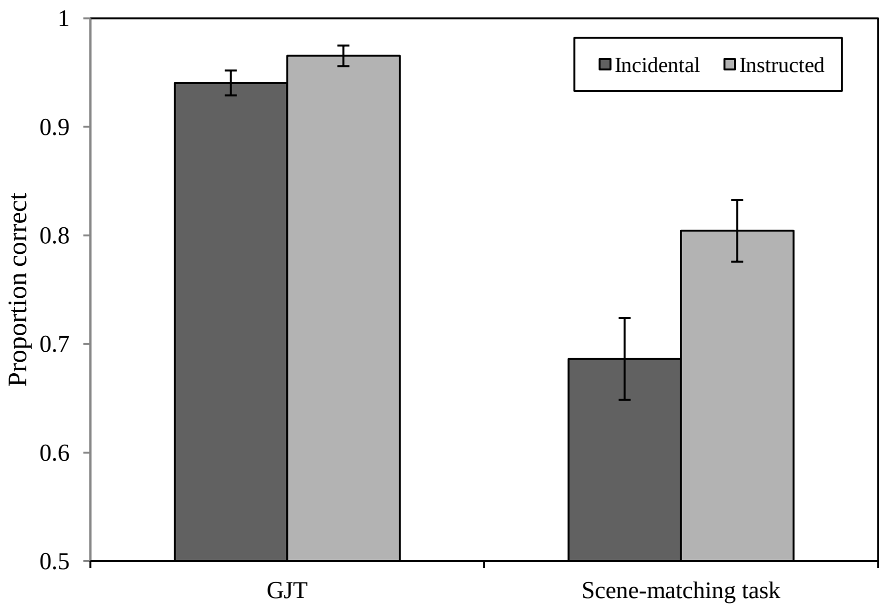


Figure 2. Performance in grammaticality judgment task (GJT) and scene-matching task.

4.*2. Scene-matching task*

Scores on this task were normally distributed; we therefore used parametric tests in this analysis. The incidental group judged .69 (*SD* = .15) of trials correctly, which was significantly above chance, *t*(14) = 4.986, *p* < .001, while the instructed group judged .80 (SD = .11) of items correctly, which was again significantly above chance, *t*(14) = 10.501, *p* < .001. That is, participants in both groups were able to use the case markers in order to accurately distinguish scene-sentence matches from mismatches. The difference between the two groups was significant, *t*(28) = 2.472, *p* = .020, *d* = .84. Simply informing participants of the existence of the case markers and explaining their function was sufficient to result in a significantly greater learning effect compared to the incidental condition (see Fig. 2).

The source attributions showed that participants in the incidental group only performed above chance when basing decisions on rule knowledge, $t(14) = 4.912$, $p < .001$, d= 2.63, r = 0.80, indicating that performance in the task was based on explicit knowledge. Participants in the instructed group performed above when basing decisions on intuition, $t(13) = 2.479$, $p = .028$, d = 1.38, r = 0.57, recollection, $t(5) = 4.862$, $p = .005$, d= 4.35, r = 0.91, and rule knowledge, $t(14) = 12.645$, $p < .001$, d= 6.76, r = 0.96. In the case of guess responses, performance from chance was marginally significant, $t(11) = 1.924$, $p = .081$, d = 1.16, r = 0.50. The source attributions thus indicate that instructed participants possessed both implicit and explicit knowledge. Table 3 in Appendix B summarizes performance on the scene-matching task across the source attribution categories.

4.3. Individual differences measures

We analyzed the effect of individual differences on the GJT and the scene-matching task by performing hierarchical linear regression analyses, with each cluster of individual difference measures entered at each step, and variables included in the model only if they significantly contributed to explaining variance. At each step, the interaction between the individual difference variable and the instruction condition were also included to determine whether the individual difference variables operated differently according to instructions. The clusters of variables were as follows. First step: NWRT and AOSPAN. Second step: ActiveReflective, SensorIntuitor, VisualVerbal, SequentialGlobal. Third step: Extraversion Agreeableness, Conscientiousness, Neuroticism, Openness to Experience. Fourth step: Visual, Auditory Kinesthetic. Fifth step: Extraverted, Introverted. Sixth step: RandomIntuitive ConcreteSequential. Seventh step: ClosureOriented, Open. Eighth step: Global, Particular. Ninth step: Synthesizing, Analytic. Tenth step: Sharpener Leveler.

For the analyses of the GJT, there was one significant predictor, total model fit was $R = .381$, $F(1,28) = 4.742$, $p = .038$. The predictor was the interaction between instruction condition and SequentialGlobal, beta = .005, SE beta = .002, *t* = 2.178, *p* = .038. This was due to a positive relationship between performance on the GJT task and the SequentialGlobal score for the instructed condition, beta = .007, SE beta = .004, and a negative relationship for the incidental condition, beta = -.003, SE beta = .003.

For the analyses of the scene-matching task, there were several significant predictors, total model fit *R* = .678, *F*(3, 26) = 7.356, *p* = .001. First, the interaction between NWRT and instruction condition was significant, beta = .015, SE beta = .004, *t* = 3.466, *p* = .002. This was due to a positive relation between scene-matching score and NWRT for the instructed condition, beta = .031, SE beta = .012, and a slight negative relation for the incidental condition, beta = -.003, SE beta = .016. Second, the interaction between Openness to Experience and instruction condition was significant, beta = -.009, SE beta = .003, t = -2.939, p = .007, with a positive relation between scene-matching task and Openness to Experience for the incidental condition, beta = .018, SE beta = .008, and a slight negative relation for the instructed condition, beta = -.004, SE beta = .004. Finally, Conscientiousness was negatively related to scene-matching task score, regardless of instruction condition, beta = -.007, SE beta = .003, t = 2.438, p = .022.

5. Discussion

In this study we compared the learning of novel syntactic word order and case-marking under two learning conditions: an instructed condition that provided learners with explicit information about grammatical case prior to exposure and an incidental condition that exposed learners to the language with no explicit information about grammatical case. We measured whether participants developed unconscious (i.e., implicit) or conscious (i.e., explicit) knowledge. Additionally, we assessed the influence of individual differences by examining phonological working memory, general working memory, personality, and learning styles.

Regarding learning conditions, our results showed successful learning of both word order and case-marking under an incidental condition, which supported our predictions and partially replicated the findings from Grey et al. (2015). In Grey et al. (2015), successful learning of case did not emerge until two weeks following exposure; immediate tests showed learning of only word order. The immediate effects for learning of both structures here may relate to differences in complexity. In Grey et al. (2015), learners had to acquire three novel case markers and their functions (subject, object, and indirect object) across both simple and complex syntactic structures. Here, only two case functions were included and only in simple sentence structures. Thus, the results from these two studies indicate that (morpho)syntactic case markers can be learned under incidental conditions, but that the time-course of learning effects may be mediated by the density of morphosyntactic information to be learned (i.e., two versus three case functions in simple and complex or only simple structures).

For the instructed condition, our results showed successful learning of word order and case-marking, which also supported our predictions and additionally aligns with previous research indicating that the provision of explicit knowledge prior to exposure is beneficial to language learning (e.g., Arciuli et al., 2014; Spada & Tomita, 2010). However, our prediction that this group would outperform the incidental group on word order and case learning was not fully borne out. The instructed condition produced superior learning effects only for case-marking, learning of word order was equivalently good for both instructed and incidental learners. The results for case-marking fit well with Tagarelli et al. (2015) in demonstrating that, when provided, explicit information in combination with exposure can be a more powerful aid to learning than implicit or incidental exposure alone.

The outcome for word order is particularly intriguing in comparison to Tagarelli et al. (2015), who found superior word order learning for their explicit compared to incidental condition. However, their explicit condition required participants to search for word order rules. In contrast, the learners in the instructed condition in this study were never instructed on any details regarding word order, they received explicit rule information only for case. It is possible, then, that word order learning across both the instructed and incidental conditions in the current study was similarly incidental in nature, as neither experimental group received any explicit information regarding word order. Alternatively, the lack of a group difference may have been due to a ceiling effect for the word order measure and future research should seek to clarify the null group difference found here for word order.

The study also gathered subjective measures of learners' awareness of their linguistic knowledge. These measures showed that participants acquired both implicit and explicit knowledge of both word order and case, irrespective of learning condition. Specifically, participants performed significantly above chance on the GJT and the scene-matching task when basing their decisions on implicit categories (e.g., guess, intuition) and explicit categories (e.g., recollection, rule knowledge). This pattern of results mirrors the findings of Rebuschat (2008, Expt. 6; Rebuschat & Williams, 2012) and several related language learning experiments which measured the conscious/unconscious status of the acquired knowledge (REFS). Moreover, the results emphasize that researchers cannot presuppose that incidental learning conditions result in implicit knowledge and more explicit conditions result in explicit knowledge (for further discussion, see Rebuschat, 2013).

With respect to the influence of IDs, the results showed that type of learning condition can mediate the effect of ID variables on the acquisition of word order and case marking. For word order learning, a global learning style preference was positively related to GJT performance under the instructed learning condition and negatively related under the incidental condition. Global learners are defined as being able to solve complex problems quickly once they have grasped the big picture, in contrast to sequential learners, who find solutions by following logical steps.

One interpretation of this effect is that the provision of case-marking rule information to the instructed learners served to provide them with enough of a linguistic ‘gist’- or big picture – to enable them to process the novel word order more effectively. The pattern for Global-sequential learning style can also be interpreted relative to the finding reported by Grey et al. (2015), who observed a marginally significant positive relationship between the GJT for incidental learning (recall that they did not test an instructed condition) and a Concrete-sequential style. Concrete-sequential learners are defined as preferring one-step-at-a-time activities and prefer to know where they are headed in their learning at each moment, similar to being a sequential learner who is more adept at finding solutions by applying logical steps. Finding the opposite effect here (negative) for a sequential style compared to Grey et al. (2015) suggests that the influence of this learning style under incidental exposure does not apply uniformly. One reason for this may be that the impact of a sequential style is conditioned by features of the learning contexts. Whereas Grey et al. (2015) asked participants to listen to the language without any added level of interactive context, the current study embedded language learning in the meaningful context of an interactive game. This may have been unfavorably ambiguous for learners who prefer to assimilate information in a linear, stepwise manner.

For grammatical case learning, the results showed that both PWM and personality variables played a significant role. Regarding PWM, the positive relationship between this memory capacity and performance on the scene-matching task is likely due to greater PWM facilitating the storage and retrieval of the explicit information about case markers throughout the experiment. More broadly, the finding provides additional evidence in support of the general pattern in adult language learning research which has implicated working memory as a key factor in learning outcomes, particularly in more explicit contexts (for a discussion, see Linck et al., 2014). The negative relationship between PWM and incidental learning runs counter to most perspectives on the relationship between working memory capacities and language learning. However, less-is-more views of working memory suggest that higher working memory is not always preferable; for example, while higher working memory seems to favor rule-based learning of categories, lower working memory has been found to favor information-integration (e.g., DeCaro, Thomas, & Beilock, 2008). The current results may be tapping into a similar pattern for PWM and grammatical case-learning under an incidental condition; future research should investigate this possibility in more detail.

In contrast to PWM, the Openness to Experience personality trait was positively related to scene-matching performance under the incidental condition and negatively related under the instructed condition. This result connects well with Kaufman et al. (2010), who observed an association between Openness to Experience and incidental learning of sequential structure. Learners with high scores on the Openness to Experience dimension tend to display a high degree of curiosity and inventiveness and a tendency to appreciate new experiences. The negative pattern for instructed group suggests that providing learners with explicit, constrained grammatical rules may not be helpful for, and may even hinder, learners who function particularly well in open situations. Finally, the Conscientiousness personality trait was negatively related to learning, irrespective of instructional condition. Conscientious individuals are thought to be organized, efficient and disciplined, which may not fit the laboratory language learning contexts that the learners in this study experienced.

Overall, our results provide new insights into the cognitive processes involved in explicit and incidental conditions in language learning, especially with respect to different aspects of language (syntax and grammatical case). We have shown that learning outcomes in these conditions are modulated distinctly by phonological working memory, learning style preferences, and personality. Ultimately, close consideration of individual differences in cognitive capacities and styles – like those examined here - enables researchers to better understand the influence of these factors in language learning under different learning instruction conditions.

5200ish words (but that includes the tables and figures).

References

Arciuli, J., Torkildsen, J., Stevens, D., & Simpson, I. (2014). Statistical learning under incidental versus intentional conditions. *Frontiers in Psychology, 5*, 747.

Baddeley, A. (2003). Working memory: looking back and looking forward. *Nature Reviews Neuroscience*, *4*(10), 829-839.

Cohen, A. D., Oxford, R. L., & Chi, J. C. (2006). Learning style survey: Assessing your learning styles Styles-and strategies-based instruction: A teacher's guide, 15–21.

DeCaro, M. S., Thomas, R. D., & Beilock, S. L. (2008). Individual differences in category learning: Sometimes less working memory capacity is better than more. *Cognition*, *107*(1), 284-294.

Gathercole, S. E., & Baddeley, A. D. (1996). *The children's test of nonword repetition*. London: Psychological Corporation.

Grey, S., Williams, J. N., & Rebuschat, P. (2015). Individual differences in incidental language learning: Phonological working memory, learning styles, and personality. *Learning and Individual Differences*, *38*, 44-53.

Linck, J. A., Osthus, P., Koeth, J. T., & Bunting, M. F. (2014). Working memory and second language comprehension and production: A meta-analysis. *Psychonomic Bulletin & Review*, *21*(4), 861-883.

Misyak, J. B., & Christiansen, M. H. (2012). Statistical learning and language: An individual differences study. *Language Learning*, *62*(1), 302-331.

Morgan-Short, K., Faretta-Stutenberg, M., Brill-Schuetz, K. A., Carpenter, H., & Wong, P. (2014). Declarative and procedural memory as individual differences in second language acquisition. *Bilingualism: Language and Cognition*, *17*(1), 56-72.

Morgan-Short, K., Finger, I., Grey, S., & Ullman, M. T. (2012). Second language processing shows increased native-like neural responses after months of no exposure. *Plos One*, *7*(3), e32974.

Morgan-Short, K., Sanz, C., Steinhauer, K., & Ullman, M. T. (2010). Second language acquisition of gender agreement in explicit and implicit training conditions: An event-related potential study. *Language Learning, 60*(1), 154-193.

Pashler, H., McDaniel, M., Rohrer, D., & Bjork, R. (2009). Learning Styles: Concepts and Evidence *Psychological Science in the Public Interest*, *9* (3), 105-119.

Rebuschat, P., & Williams, J. N. (2012). Implicit and explicit knowledge in second language acquisition. *Applied Psycholinguistics*, *33*(04), 829-856.

Siegelman, N., & Frost, R. (2015). Statistical learning as an individual ability: Theoretical perspectives and empirical evidence. *Journal of Memory and Language*, *81*, 105-120.

Soloman, B. A., & Felder, R. M. (2005). Index of learning styles questionnaire. Retrieved from *http://www. engr. ncsu. edu/learningstyles/ilsweb*

Spada, N., & Tomita, Y. (2010). Interactions between type of instruction and type of language feature: A Meta-Analysis. *Language learning*, *60*(2), 263-308.

Speciale, G., Ellis, N. C., & Bywater, T. (2004). Aspects of working memory in L2 learning. *Applied Psycholinguistics, 25*, 293-321.

Tagarelli, K. M., Borges Mota, M., & Rebuschat, P. (2015). Working memory, learning conditions, and the acquisition of L2 Syntax. In W. Zhisheng, M. Borges Mota, & A. McNeill (Eds.) *Working Memory in Second Language Acquisition and Processing: Theory, Research and Commentary*. *Multilingual Matters*.

Tagarelli, K.M., Ruiz-Hernandez, S., Vega, J.L.M., & Rebuschat (forthcoming 2016). Variability in second language learning: The roles of individual differences, learning conditions, and linguistic complexity. *Studies in Second Language Acquisition*.

Unsworth, N., Heitz, R. P., Schrock, J. C., & Engle, R. W. (2005). An automated version of the operation span task. *Behavior Research Methods*, *37*(3), 498-505.

Violand-Sanchez, E. (1995). Cognitive and learning styles of high school students: Implications for ESL curriculum development. *Learning styles in the ESL/EFL classroom*, 158-168.

Appendix A

The Learning Style Survey (Cohen, Oxford & Chi, 2006) consists of 110 items which allow for the identification of respondents' general learning style by determining the degree to which 23 different characteristics apply to them. The questionnaire is divided into 11 parts, each assessing the learner in terms of one of the following groups of characteristics.

1. Sensory style preferences: visual, auditory, kinaesthetic
2. Extraverted vs. introverted
3. Random-intuitive vs. concrete-sequential
4. Closure-oriented vs. open
5. Global vs. particular
6. Synthesizing vs. analytic
7. Sharpener vs. leveler
8. Deductive vs. inductive
9. Field-independent vs. field-dependent
10. Impulsive vs. reflective
11. Metaphoric vs. literal

Appendix B

Table B1

Performance (mean accuracy and proportions) in the grammaticality judgment task across source attribution categories.

Group		Guess	Intuition	Recollection	Rule knowledge
Incidental	M (SD)	0.71* (0.22)	0.81** (0.22)	0.95** (0.12)	0.98** (0.02)
	Prop	0.07	0.14	0.14	0.65
Instructed	M (SD)	0.65† (0.42)	0.81** (0.32)	0.92** (0.19)	1.00** (0.01)
	Prop	0.03	0.23	0.26	0.68

Note: † p = .064, * $p < .05$, ** $p < .001$. Prop = proportion.

Table B2

Performance (mean accuracy and proportions) in the scene-matching task across source attribution categories

Group		Guess	Intuition	Recollection	Rule knowledge
Incidental	M (SD)	0.49 (0.34)	0.61 (0.25)	0.66 (0.34)	0.73* (0.18)
	Prop	0.10	0.18	0.17	0.54
Instructed	M (SD)	0.68† (0.33)	0.70* (0.31)	0.86* (0.18)	0.86* (0.11)
	Prop	0.07	0.21	0.08	0.65

Note: † p = .081, * $p < .05$, ** $p < .001$. Prop = proportion.