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Corresponding Author:	Xinmiao Liu Beijing Foreign Studies University BEIJING, OVERSEAS ONLY CHINA
Corresponding Author's Institution:	Beijing Foreign Studies University
Corresponding Author E-Mail:	liuxinmiao929@hotmail.com
Order of Authors:	Xinmiao Liu
	Wenbin Wang
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TITLE:

Experimental Paradigm for Measuring the Effect of Induced Emotion on Grammar Learning

AUTHORS AND AFFILIATIONS:

Xinmiao Liu[1], Wenbin Wang[2], Anni Xie[3]

[1]School of English for Specific Purposes, Beijing Foreign Studies University, Beijing, China
[2]National Research Centre for Foreign Language Education, Beijing Foreign Studies University, Beijing, China
[3]School of European Languages and Cultures, Beijing Foreign Studies University, Beijing, China

Corresponding Author:
Wenbin Wang (wangbode88@163.com)

Email Address of Co-authors:
Xinmiao Liu (liuxinmiao929@hotmail.com)
Anni Xie (xan_2009@126.com)

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SUMMARY:
Here, we present a protocol to measure the effect of positive induced emotion on grammar learning in foreign language learners using a semi-artificial language that integrates the grammatical rules of a foreign language with the lexicon of the learners' native language.

ABSTRACT:
Previous studies have found that emotion has significant influence on the learning of foreign language vocabulary and textual comprehension. However, little attention has been given to the effect of induced emotion on grammar learning. This research examined the influence of positive induced emotion on the learning of Japanese grammatical rules among a group of learners with Chinese as their native language, using a semi-artificial language (i.e. *Chipanese*), which combines the grammatical rules of Japanese and the vocabulary of Chinese. Music was used to invoke positive emotional conditions in participants. Participants were required to learn Chipanese sentences in a training session through practice and then a grammaticality judgment task was administered to measure learning outcomes. We found that participants in positive emotional states performed less accurately and efficiently than those in the control group. Positive emotion had an inhibitory effect on the learning of foreign language grammar. The findings suggest that the protocol is effective in identifying the effect of positive induced emotion on grammar learning. The implications of this experimental paradigm for investigating foreign language learning are discussed.

INTRODUCTION:

Emotions play a crucial role in various cognitive activities such as perception, learning, reasoning, memorization, and problem solving. Because language learning requires attention, reasoning, and memorization, emotions may have significant influence on language learning outcomes[1]. Several prior studies have explored the effect of induced emotions on word production or text comprehension[2,3], and have consistently found that emotion had a crucial influence on the two language processes. For example, Egidi and Caramazza found that positive emotion increased the sensitivity to inconsistency in text comprehension in the brain areas specific for inconsistency detection, whereas negative emotion increased the sensitivity to inconsistency in less specific areas[2]. Hinojosa et al. examined the effect of induced mood on word production and discovered that negative mood impaired the retrieval of phonological information during word production[3]. In spite of the evidence showing that emotions have a marked impact on text comprehension and word production, it is still not clear whether emotions affect grammar learning, one of the essential aspects of language learning. The present study aimed to explore the effect of learners' emotional states on grammar learning.

Language and emotion are two primary components of human experience[4]. Their relationships have mostly been explored by studies in affective neurolinguistics. At the single word level, previous studies have consistently found that emotional features, such as arousal or valence, significant affect the processing of individual words[5,6,7]. Specifically, some studies have identified a significant advantage for positive words[5], and other studies have found an advantage for both positive and negative words[7]. Although some studies have reported an interaction between valence and arousal, a lack of significant interaction was reported in other research[4]. The picture is more complex at the level of sentence processing. Previous studies have explored issues concerning the interaction between emotional content and syntactic or semantic unification processes during sentence comprehension. Emotional information has been found to exert different influences on the processing of gender or number features[4]. Further, positive and negative emotion was connected with different agreement effects[4]. For instance, positive emotional features facilitated number agreement processing, whereas negative emotional features inhibited these processes[4]. At the semantic level, emotional features influenced semantic unification processes in both sentence and discourse contexts through the activation of the brain regions involved in single word processing and combinatorial semantic processes[4]. A review of the previous literature indicates that most prior research has focused on the effects of emotional information on the comprehension of words, sentences, and texts[8,9], or the neural basis of emotional effects on language production[10,11]. However, how individuals' affective states might influence language processing or learning has been largely overlooked.

The most frequently used approach to the studies of emotions in grammar learning is the artificial grammar learning paradigm. Several studies have used artificial grammar tasks to examine the effect of emotion on the learning of a new language[12]. First introduced by Reber in 1967[13], the artificial grammar learning paradigm is characterized by the use of non-meaningful materials, such as number strings or non-word letter strings, which are in fact generated by an underlying grammar. Researchers usually exposed participants in different emotional states (positive, neutral, or negative) to the number strings or letter strings presented either visually or audibly and measured their learning outcomes. Studies with the artificial grammar approach typically consist of a training session and a testing session. In the training session, participants are instructed to observe or memorize a list of symbol sequences that are generated from a finite state grammar. Participants are informed that the sequences follow a particular set of rules, but they are not given any details regarding these rules. In the testing session, participants are presented with new symbol sequences, some of which are grammatical and others are not. They are then required to judge whether the strings are grammatical or not. Artificial grammar tasks allow the instantiation of various theories of learning, such as rules, similarity, and associative learning theories[14]. This approach can effectively minimize the influence of lexical factors on the learning of grammatical rules, as artificial languages are made up of numbers, letters, or other meaningless symbols, rather than words in natural languages. However, many researchers have argued that the knowledge acquired in artificial grammar learning may represent statistical properties that are different from the features of natural grammar used by human beings[15]. Evidence from neurological studies shows that the grammars in natural languages are processed differently from the finite-state grammars used in artificial grammar learning tasks[16,17]. Therefore, artificial grammar learning tasks may not reflect the learning of human languages. Studies of the emotion effect on grammar learning using artificial grammars are more likely to reveal how emotion influences statistical learning, rather than the learning of natural grammars in human languages. It is not entirely clear whether findings from the meaningless stimuli can be generalized to foreign language learning.

The present study intended to adopt a semi-artificial language task to investigate the effect of emotion on grammar learning. Semi-artificial language tasks were first introduced by Williams and Kuribara to examine language learning. A semi-artificial language is generated with the combination of lexicon in the learners' native language and the grammar of a different language. An example of such language can be found in Williams and Kuribara's study[18]. Williams and Kuribara designed a novel semi-artificial language, *Japlish*, which followed the word order and case-marking rules of Japanese but used English vocabulary[15]. Sample *Japlish* sentences in their study are provided in **Table 1**.

[Place **Table 1** here]

As shown in the table, although English words are used, they are combined into sentences in accordance with the Japanese word order and case-marking rules. The *Japlish* sentences are all verb-final and nouns are case-marked for subject (-ga), indirect object (-ni), or object (-o). A detailed description of *Japlish* can be found in Grey et al.'s study[17]. Semi-artificial language tasks involve a training phase and a testing phase. During the training phase, participants are instructed to learn a new language, and in the testing phase, they are required to perform acceptability judgment tasks or sentence-picture matching tasks. The accuracy and reaction times (RTs) of their responses are recorded to assess their learning performance.

Semi-artificial language tasks have mainly three advantages: First, as semi-artificial languages are created using grammatical rules in a new language, the tasks can minimize the influence of prior knowledge of the structures as well as language transfer[19]. Second, the tasks enable us to control and manipulate the type and amount of exposure participants receive[19]. In this way, they allow for more accurate assessment of the learning effects. Finally, as the grammars used in semi-artificial language tasks are from human languages, the tasks allow us to measure how participants acquire natural grammars, rather than artificial ones. In this aspect, they are more advantageous than artificial grammar tasks in which sequences of numbers or letters are used instead of real words. The use of natural grammar makes us more confident to conclude that the findings obtained are applicable to natural language learning. Given that prior studies have demonstrated learning effects using the semi-artificial language paradigm[20,21,22], it is a useful approach to investigating issues in language learning that are difficult to isolate in the complex context of natural language research. However, semi-artificial language tasks are only applicable to foreign languages that are structurally different from learners' native languages. If the tested language is structurally similar to the learners' native language, it might make the former indistinguishable from the latter.

Compared with the tasks using natural languages, semi-artificial language tasks allow for a more objective assessment of the effects of emotion on grammar learning. This is because words in natural languages are closely associated with specific grammatical functions. For example, inanimate nouns (e.g., desk, nail) are more likely to function as the patients of verbs. Thus, it is difficult to differentiate the performance of vocabulary learning from that of grammar learning because the two are interrelated and inseparable in natural languages. As emotions have been found to have vital influence on vocabulary learning[23,24], they may have indirect influence on grammar learning. Therefore, it is not easy to clearly differentiate the effect of emotion on vocabulary learning from that on grammar learning. This problem can be easily solved in semi-artificial language tasks because these tasks allow for the separation of vocabulary from grammar, and thus enable us to identify the effect of emotion on grammar learning, without having to worry about the interference from lexical learning.

Although the semi-artificial language paradigm has been used in some studies to investigate linguistic knowledge in second language acquisition[25,26], this approach has rarely been used to explore learners' individual differences in emotional conditions in foreign language learning. In this study, we intended to explore how positive induced emotion influences grammar learning using a semi-artificial language. Findings from this study have important implications for foreign language teaching and learning.

PROTOCOL:

The experiment was approved by the Ethics Committee of Beijing Foreign Studies University and it complied with the guideline for experiments with human subjects. All subjects in this research provided written informed consent.

1. Stimuli construction

1.1. Design experimental stimuli based on the specific research questions. As this study is intended to examine foreign language learning using a semi-artificial language, create the experimental sentences by rearranging sentences in the participants' native language in accordance with the grammatical rules of the tested foreign language. Sample experimental sentences are provided in **Table 2**.

[Place **Table 2** here]

NOTE: As our study was intended to investigate the learning of Japanese grammar by Chinese learners, a semi-artificial language (*Chipanese*) was generated with the vocabulary of Chinese and the syntax of Japanese. The experimental sentences were adapted from the experimental stimuli used in Liu, Xu, and Wang[27].

1.2. Select representative grammatical structures in the tested language. Make sure to include a variety of grammatical structures to maintain the grammatical complexity and diversity of a natural language.

NOTE: Four grammatical structures were tested in our study, including two simple grammatical structures (SOV [subject-object-verb], SIOV [subject-indirect object-verb]) and two complex ones ([SOV]SV, [OSV]SV). The lexical frequency of nouns and verbs was matched between different types of sentences.

1.3. For the training phase, design at least 20 sentences for each grammatical structure in the tested language for the grammaticality judgment task. The grammatical and ungrammatical sentences should be counterbalanced and controlled for lexical variables such as lexical frequency and number of strokes.

1.4. For the testing phase, design at least 12 sentences for each grammatical structure in the tested language. Make half of the sentences grammatical and the other half ungrammatical. The grammatical and ungrammatical sentences should be counterbalanced and controlled for lexical variables.

1.5. Randomize the sentences and design the experiment.

1.5.1. Randomize the sentences before presenting them to the participants in both the training phase and the testing phase. Find the '**Selection**' tab on the Property Page in the stimulus presentation software and set the selection method to '**Random**'.

1.5.2. Divide the experiment into blocks with each lasting for no more than 10 min.

2. Participant recruitment and preparation for the experiment

2.1. Recruit participants who have no reading difficulties and no background in the foreign language that will be tested. Make sure participants have normal or corrected-to-normal vision.

2.2. Randomly assign the participants into two groups (an experimental group and a control group), with each group containing at least 30 members. Ensure the two groups do not differ in years of education or gender ratio.

2.3. Inform the participants that they should be free from exhaustion, hunger, illness, or other conditions that make them uncomfortable on the day of the experiment.

2.4. Invite the participants individually or in groups to the laboratory.

3. Procedure

3.1. Take the participants to the laboratory room and instruct them to sit down at computer workplaces.

3.2. Ask the participants to read and sign the written informed consent forms.

3.3. Have the participants complete emotion induction.

3.3.1. Give the participants the pencil-and-paper version of the Self-Assessment Manikin (SAM) pictorial rating scale[28,29]. Ask participants to rate their emotion by using pencils to mark the corresponding manikin.

NOTE: The Self-Assessment Manikin scale is a non-verbal assessment tool to measure the three dimensions of emotion (i.e., valence, arousal, and dominance). The scale we administered was a nine-point scale that ranges from one to nine in each of the three dimensions.

3.3.2. Instruct participants in the experimental group to listen to the positively-valenced music through headphones for 10 min.

NOTE: In this study, *Good Time* was used to induce positive emotion. A pilot study was implemented in a group of 20 participants to test the validity of the music in emotional induction, and results indicated that participants rated their emotion as significantly more positive after the induction, which showed that the music was effective in placing participants in the positive affective state. Participants in the control group were not exposed to any emotionally-loaded materials. Rather, they proceeded directly to the learning task.

3.3.3. Give participants the pencil-and-paper version of the Self-Assessment Manikin scale[28,29] and ask them to rate their emotional states.

3.4. Ask participants to perform the training task.

3.4.1. Present the following written instructions on the computer screens to inform participants that they will learn a language containing the vocabulary in their native language and a new grammar: “Welcome to our experiment! In this experiment, you will be required to learn a novel language that contains Chinese words and a new grammar. When you are ready, press any key to proceed to the experiment.”

3.4.2. Present the following written instructions on the computer screens to instruct participants to perform the learning task: "Next, you will see some sentences on the screen. Please observe them carefully and decide whether they are grammatical or not. Press '1' if the sentences are grammatical, and '0' if they are ungrammatical. After each response, you will receive a feedback reply ('CORRECT!' or 'INCORRECT!') and the correct sentence will be presented. Press any key to proceed to the learning task."

3.4.3. Have the participants judge the grammatical acceptability of the sentences on the computer screen with a press of the button ('1' for grammatical and '0' for ungrammatical) and present a reply ('CORRECT!' or 'INCORRECT!') on the screen after each response. Present the correct structures after the replies to reinforce the effect of learning.

3.4.4. When all trials are completed, present the following written instructions on the computer screens to inform participants that the training task is over: "The learning task is completed!"

3.5. Give participants the pencil-and-paper version of the Self-Assessment Manikin scale[28,29] and ask them to rate their emotional conditions.

3.6. Ask participants to perform the grammaticality judgment task for the testing session.

3.6.1. Present the following written instructions on the computer screens: "Please continue to answer similar questions. Please decide whether the grammatical structures of the sentences are correct. Press 1 if you think they are correct and press 0 if you think they are incorrect. You will be given seven seconds to respond. If you fail to respond with the time limit, the next question starts automatically. Press any key to start the experiment."

3.6.2. Have participants read the sentences shown on the screen and judge the grammaticality of the sentences with a button press ("1" for grammatical and "0" for ungrammatical).

3.6.3. When all trials are completed, present the following written instruction on the computer screens to inform participants that the task is over: "The end. Thank you for your participation!"

3.7. Ask the participants to fill in a questionnaire about their demographic details. Prepare their payment during the questionnaire.

3.8. Provide the monetary compensation or reward to the participant.

4. Data analysis

4.1. Collect data from the output files from the stimulus presentation software.

4.2. Perform an ANOVA analysis with emotion (positive, control) and sentence type (SOV, SIOV, OSVSV, SOVSV) as the independent variables and the average accuracy of learning as the dependent variable to explore the effect of emotion on accuracy.

4.3. Perform an ANOVA analysis with emotion (positive, control) and sentence type (SOV, SIOV, OSVSV, SOVSV) as the independent variables and the average RTs as the dependent variable to explore the effect of emotion on RTs.

RESULTS:

The aim of this study is to explore the effect of positive induced emotion on foreign language grammar learning. For this purpose, two groups of participants were recruited to participate in the experiment, including a positive-emotion group (15 female, M_{age}= 20.20, age range: 18 – 27) and a control group (16 female, M_{age}= 20.33, age range: 18 – 26). Each group consisted of 30 participants. The two groups did not differ in age, t (58) = -0.215, p = 0.831 or years of education, t (58) = -0.830, p = 0.410. None of them reported to have learned Japanese before. Music was used to induce positive emotions. After emotion induction, participants were required to learn a novel language, *Chipanese*, which was generated with Chinese vocabulary and Japanese grammar. The participants learned the language through a grammaticality judgment task during which they were asked to judge the grammaticality of the sentences, with feedback provided after each response. To assess the learning outcomes, we administered an acceptability judgment task during which participants were presented with new Chipanese sentences, some of which were grammatical and others were not. The participants were asked to decide whether the sentences were grammatical or not. The accuracy and RTs of their responses were recorded and analyzed to assess their learning performance.

To find out whether emotion induction was successful, a repeated-measures ANOVA was performed with time (before induction vs. after induction) and group (positive vs. control) with predictors and rating scores as the dependent variable. The analysis revealed a significant main effect of time, $F(1, 58) = 25.91$, $p < 0.001$; a significant main effect of group, $F(1, 58) = 12.62$, $p < 0.001$; and a significant interaction effect between time and group, $F(1, 58) = 28.03$, $p < 0.001$. Pair-wise comparison showed that the valence ratings for the control group did not change significantly after induction ($p < 0.001$). Participants in the control group were in a relatively neutral emotional condition both before and after the induction. The ratings for the positive-emotion group increased significantly after the induction with the positively-valenced music ($p < 0.001$). Participants in the positive-emotion group were significantly happier than those in the control group ($p < 0.001$). Therefore, our emotion induction was successful (**Figure 1**).

[Place **Figure 1** here]

To explore whether emotional states were sustained during the training phase, we performed a repeated-measures ANOVA with group (positive vs. control) and time (after induction vs. after training) as predictors and rating scores as the dependent variable. Results indicate that there was a significant main effect of group, $F(1, 58) = 52.96$, $p < 0.001$. The average rating scores for the positive-emotion group were significantly higher than those for the control group, which suggested that the positive-emotion group was significantly happier than the control group. No significant effect of time was found, $F(1, 58) =.61$, $p = 0.436$, which indicated that valence ratings for the two groups did not change significantly during the training phase and the positive-emotion participants remained happier than the controls during this period. Results indicated that participants' emotional conditions were sustained throughout the experiment.

[Place **Figure 2** here]

The mean accuracy of grammar learning by the two groups is presented in **Figure 2**. ANOVA was performed with emotion (positive, control) and sentence type (SOV, SIOV, OSVSV, SOVSV) as the predictors and mean accuracy as the dependent variable. Results revealed a significant effect of emotion, $F(1, 58) = 62.68$, $p < 0.001$; and a significant effect of sentence type, $F(1, 58) = 35.21$, $p < 0.001$. The interaction between emotion and sentence type was not statistically significant, $F(1, 58) = 1.71$, $p = 0.165$. The participants in the control group performed significantly more accurately than those in the positive emotion condition. SIOV and SOVSV structures were comprehended significantly less accurately than SOV and OSVSV structures. The control group performed better than the positive-emotion group regardless of the grammatical structures.

[Place **Figure 3** here]

The mean RTs for the two groups are shown in **Figure 3**. Before analysis, the RTs for incorrect responses were removed. RTs above three standard deviations from the mean were considered as outliers and excluded from analysis. ANOVA was performed with emotion (positive, control) and sentence type (SOV, SIOV, OSVSV, SOVSV) as the predictors and RTs as the dependent variable. Results showed that there was a significant effect of emotion, $F(1, 58) = 600.81$, $p < 0.001$; and a significant effect of sentence type, $F(1, 58) = 77.03$, $p < 0.001$. The interaction between emotion and sentence type was not significant, $F(1, 58) = 1.70$, $p = 0.165$. The participants in the control group reacted faster than those in the positive emotional states. SOV structures were recognized faster than the other three structures, and SIOV structures were recognized more slowly than other structures. However, the effect of emotion did not differ significantly across different structures. The positive-emotion group reacted significantly more slowly than the control group in all the structures tested.

FIGURE AND TABLE LEGENDS:

Figure 1: Results of emotion induction. The figure presents the mean rating scores for the emotional conditions of the two groups. The error bars represent the standard deviation of the data.

Figure 2: **Accuracy of grammar learning by group.** The figure presents the mean proportion of correct answers by the positive-emotion group and the control group. The error bars represent the standard errors of the data.

Figure 3: **Reaction times in grammar learning by group.** The figure presents the mean RTs by the positive-emotion group and the control group. The error bars represent the standard errors of the data.

Table 1. **Sample sentences in a semi-artificial language.** The sentences were generated with

English lexis and Japanese syntax. The sentences in the table are from Williams and Kuribara's study[18].

Table 2. **Sample experimental sentences used in this study.** Sentence (**A**) is a Chinese sentence and (**B**) is its Japanese equivalent. Sentence (**C**) is the experimental stimuli generated by rearranging sentence (**A**) in accordance with the syntactic structure of (**B**). This semi-artificial language was first designed by Liu, Xu, and Wang[27].

DISCUSSION:

The results indicate that participants rated their emotions to be significantly more positive after being exposed to the positively-valenced music. These subjects were significantly happier than the control group. This suggests that our emotion manipulation was successful. Participants in the positive-emotion group were found to be significantly less accurate and efficient than those in the control group. One possible reason is that participants employed an inductive strategy in grammar learning, resulting in a strong reliance on analytical and bottom-up processing. Inductive processing involves the careful consideration of detailed information and the use of analytical strategies to process information. Deductive processing, on the other hand, involves the use of heuristic strategies which features a strong reliance on previous experience to speed up the problem-solving process. As grammar learning is a process that requires the consideration of the relationships between different linguistic units and the extraction of the rules governing these relationships, inductive processing is a more facilitative processing style than deductive processing. Previous studies have found that the inductive approach is an effective approach to learning foreign language grammar[30]. In the present study, we manipulated the word order and case-marking of the experimental sentences, which are essential aspects of grammar. This learning task required participants to analyze and identify the relationships between different words in the sentences and form judgments about the legitimate order of the words in the sentences. Most importantly, these judgments must be based on the careful observation and analysis of specific linguistic details such as syntactic categories or semantic roles. Therefore, word order learning benefited more from inductive strategies and the corresponding bottom-up processing style. As positive emotion fosters a deductive or top-down processing style[31,32], which is incompatible with the inductive approach used by participants, it may have an inhibitory effect on participants' performance in grammar learning. Another possible reason is that individuals in positive emotional conditions tend to process information in a less effortful way[33,34]. According to the motivational principles, individuals in positive affective conditions are less motivated to make great efforts because they are more inclined to maintain their affective states by avoiding cognitive efforts[35]. Therefore, learners in the positive emotional condition may be less motivated than the controls, which might explain why they performed worse in the experimental task. The findings are consistent with Politis and Houtz's study[36] and Liu et al.'s study[27], which found that learners in positive emotional conditions performed less accurately and carefully in learning activities. The findings from this study showed that the protocol was successful in identifying the effect of artificially induced positive emotion on foreign language grammar learning.

In terms of methodology, the experiment was based on the semi-artificial language paradigm. The semi-artificial language was chosen in order to ensure that the tested structures were novel to participants. This study is different from traditional artificial language studies in the following two aspects: First, we adopted a target language system that followed the grammatical rules of a natural language (Japanese). Second, the lexicon used in the target language system consisted of real words (Chinese), rather than meaningless number or letter strings. These two features increased the similarity of the semi-artificial language to natural languages used by human beings. The use of semi-artificial languages can maintain the grammatical complexity and the semantic information in natural languages, and thus can better reveal how participants' individual differences in affective states influence their learning of grammatical rules in natural languages. Therefore, the findings from the present study are generalizable to foreign language learning outside the laboratory.

By combining the vocabulary in the learners' native language with the grammar in a foreign language, semi-artificial language tasks can effectively separate the two learning processes and differentiate the effect of emotion on grammar learning from that on vocabulary learning. Compared with natural languages, semi-artificial languages can minimize the interference of lexical factors in grammar learning, and thus allow for more objective assessment of learning outcomes. Semi-artificial language tasks have been used in several studies and were found to be an effective approach to studying the implicit or incidental learning of syntax or morphosyntax in non-native languages[19].The present study demonstrated that this approach is also applicable to the investigations into learners' individual differences in non-native language learning.

A major problem with this protocol is the lack of a priori measures that ensure similar processing of grammaticality and of learning in the absence of any emotion manipulation in the two groups. An ideal protocol should include a series of pretest manipulations that allow for unambiguously demonstrating that the two groups learn grammar similarly in the absence of emotion induction. For example, we would administer a grammaticality judgment task and a word-order learning task using another foreign language and compare the performance of the two groups. They should only be allowed to proceed to the experiment if no significant difference is found between the two groups. Results of this study would be more convincing if we were able to demonstrate, prior to the experiment, that the two groups did not differ in basic aspects that could have biased their behavioral responses. This is a step that has been ignored in our protocol and should be closely considered in future studies. Another limitation is that it is only applicable to the languages that are grammatically different from the learners' native languages. If the foreign language has similar grammatical structures as the learner's native language, the resulting semi-artificial language will contain the same vocabulary and similar grammar as their native language, making it difficult to distinguish between the two. For those languages that are similar to learners' native languages, it is preferable to use artificial language tasks in which sequences of letters or numbers are used instead of words. Besides, as this research has only examined the effect of artificially induced positive emotion on grammar learning, the results may not necessarily hold the same for negative affective states. Further studies are needed to explore how negative affective states might influence foreign language learning using the semi-artificial language paradigm.

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DISCLOSURES:

The authors declare that they have no competing interests.

REFERENCES:

1. Arnold, J. (Ed.). *Affect in Language Learning*. Cambridge University Press, Cambridge (1999).

2. Egidi, G., Caramazza, A. Mood-dependent integration in discourse comprehension: Happy and sad moods affect consistency processing via different brain networks. *NeuroImage*. **103**, 20–32 (2014).

3. Hinojosa, J. A. et al. Negative induced mood influences word production: An event-related potentials study with a covert picture naming task. *Neuropsychologia*. **95**, 227–239 (2017).

4. Hinojosa, J. A., Moreno, E. M., Ferré, P. Affective neurolinguistics: towards a framework for reconciling language and emotion. *Language, Cognition and Neuroscience*. 1–27 (2019).

5. Kuperman, V., Estes, Z., Brysbaert, M., Warriner, A. B. Emotion and language: valence and arousal affect word recognition. *Journal of Experimental Psychology: General*. **143** (3), 1065–1081 (2014).

6. Rodríguez-Ferreiro, J., Davies, R. The graded effect of valence on word recognition in Spanish. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. (2018).

7. Vinson, D., Ponari, M., Vigliocco, G. How does emotional content affect lexical processing? *Cognition and Emotion*. **28** (4), 737–746 (2014).

8. Kotz, S. A., Kalberlah, C., Bahlmann, J., Friederici, A. D., Haynes, J. D. Predicting vocal emotion expressions from the human brain. *Human Brain Mapping*. **34** (8), 1971–1981 (2013).

9. Wegrzyn, M., Herbert, C., Ethofer, T., Flaisch, T., Kissler, J. Auditory attention enhances processing of positive and negative words in inferior and superior prefrontal cortex. *Cortex*. **96**, 31–45 (2017).

10. Cato, M. A. et al. Processing words with emotional connotation: an FMRI study of time course and laterality in rostral frontal and retrosplenial cortices. *Journal of Cognitive Neuroscience*. **16** (2), 167–177 (2004).

11. Hinojosa, J. A., Méndez-Bértolo, C., Carretié, L., Pozo, M. A. Emotion modulates language production during covert picture naming. *Neuropsychologia*. **48** (6), 1725–1734 (2010).

12. Larsen, K. G. The relationship between mood and implicit learning. Doctorate thesis, University of Nevada (2017).

13. Reber, A. S. Implicit learning of artificial grammars. *Journal of Verbal Learning and Verbal Behavior*. **6**, 855–863 (1967).

14. Ziori, E., Pothos, E. Artificial grammar learning: An introduction to key issues and debates. In *Implicit and Explicit Learning of Languages*. Edited by Rebuschat P., 249–273, John Benjamins Publishing Company. Amsterdam (2015).

15. Opitz, B., Hofmann, J. Concurrence of rule- and similarity-based mechanisms in artificial grammar learning. *Cognitive Psychology*. **77**, 77–99 (2015).

16. Bahlmann, J., Gunter, T. C., Friederici, A. D. Hierarchical and linear sequence processing: An electrophysiological exploration of two different grammar types. *Journal of Cognitive Neuroscience*. **18**, 1829–1842 (2006).
17. Friederici, A. D., Bahlmann, J. H. S., Schubotz, R. I., Anwander, A. The brain differentiates human and nonhuman grammars: Functional localization and structural connectivity. *Proceedings of the National Academy of Sciences of the United States of America*. **103**, 2458–2463 (2006).
18. Williams, J. N., Kuribara, C. Comparing a nativist and emergentist approach to the initial stage of SLA: An investigation of Japanese scrambling. *Lingua*. **118**, 522–553 (2008).
19. Grey, S., Williams, J. N., Rebuschat, P. Individual differences in incidental language learning: Phonological working memory, learning styles, and personality. *Learning and Individual Differences*. **38**, 44–53 (2015).
20. Williams, J. N. Learning without awareness. *Studies in Second Language Acquisition*. **27**, 269–304 (2005).
21. Leung, J. H. C., Williams, J. N. The implicit learning of mappings between forms and contextually derived meanings. *Studies in Second Language Acquisition*. **33**, 33–55 (2011).
22. Leung, J. H. C., Williams, J. N. Constraints on implicit learning of grammatical form-meaning connections. *Language Learning*. **62**, 634–662 (2012).
23. Pratt, N. L., Kelly, S. D. Emotional states influence the neural processing of affective language. *Social Neuroscience*. **3** (3–4), 434–442 (2008).
24. Chwilla, D. J., Virgillito, D., Vissers, C. T. W. The relationship of language and emotion: N400 support for an embodied view of language comprehension. *Journal of Cognitive Neuroscience*. **23** (9), 2400–2414 (2011).
25. Williams, J. N., Paciorek, A. Indirect tests of implicit linguistic knowledge. In *Advancing Methodology and Practice: The IRIS Repository of Instruments for Research into Second Languages*. Edited by Mackey, A. and Marsden, E., 25–42, Taylor & Francis (2016).
26. Rebuschat, P., Williams, J. N. Implicit and explicit knowledge in second language acquisition. *Applied Psycholinguistics*. **33**, 829–856 (2012).
27. Liu, X., Xu, X., Wang, H. The effect of emotion on morphosyntactic learning in foreign language learners. *PloS One*. **13** (11), e0207592 (2018).
28. Hodes, R., Cook, E. W. III, Lang, P. J. Individual differences in autonomic response: conditioned association or conditioned fear? *Psychophysiology*. **22**, 545–560 (1985).
29. Lang, P. J. Behavioral treatment and bio-behavioral assessment: computer applications. In *Technology in mental health care delivery systems*. Edited by Sidowski, J. B., Johnson, J. H., Williams, T. A., 119–137. Ablex, Norwood, NJ. (1980).
30. Vogel, S., Herron, C., Cole, S. P., York, H. Effectiveness of a guided inductive versus a deductive approach on the learning of grammar in the intermediate - level college French classroom. *Foreign Language Annals*. **44** (2), 353–380 (2011).
31. Storbeck, J., Clore, G. L. On the interdependence of cognition and emotion. *Cognition and Emotion*. **21** (6), 1212–1237 (2007).
32. Clore, G. L., Storbeck, J. Affect as information about liking, efficacy, and importance. In *Affect in Social Thinking and Behavior*. Edited by Forgas, J.P., 123–141, Psychology Press, New York (2006).
33. Clark, M. S., Isen, A. M. Towards understanding the relationship between feeling states

and social behavior. In *Cognitive Social Psychology*. Edited by Hastorf, A. H. & Isen, A. M., 73–108. Elsevier-North Holland, New York (1982).

34. Sinclair, R. C., Mark, M. M., Clore, G. L. Mood-related persuasion depends on (mis)attributions. *Social Cognition*. **12**, 309–326 (1994).

35. Forgas, J. P. Can sadness be good for you? On the Cognitive, Motivational, and Interpersonal Benefits of Negative Affect. In *The Positive Side of Negative Emotions*. Edited by Parrott W. G., 3–35. Guilford Publications, New York (2014).

36. Politis, J., Houtz, J. C. Effects of positive mood on generative and evaluative thinking in creative problem solving. *SAGE Open*. **5** (2), 2158244015592679 (2015).

Figure 1 Click here to access/download;Figure;Figure 1.pdf

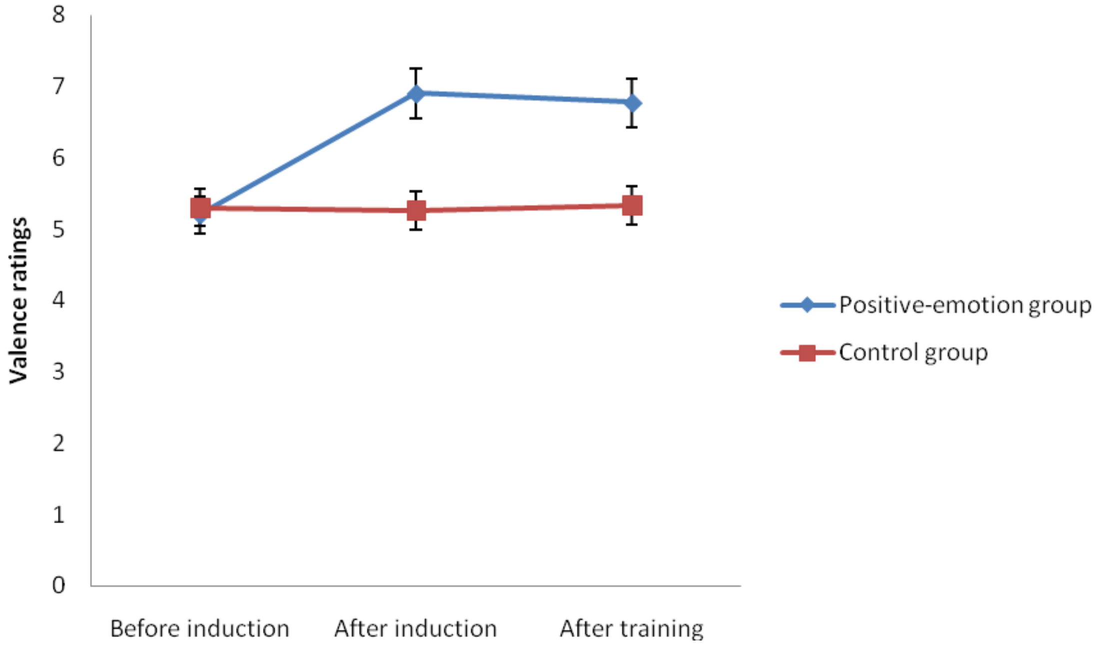
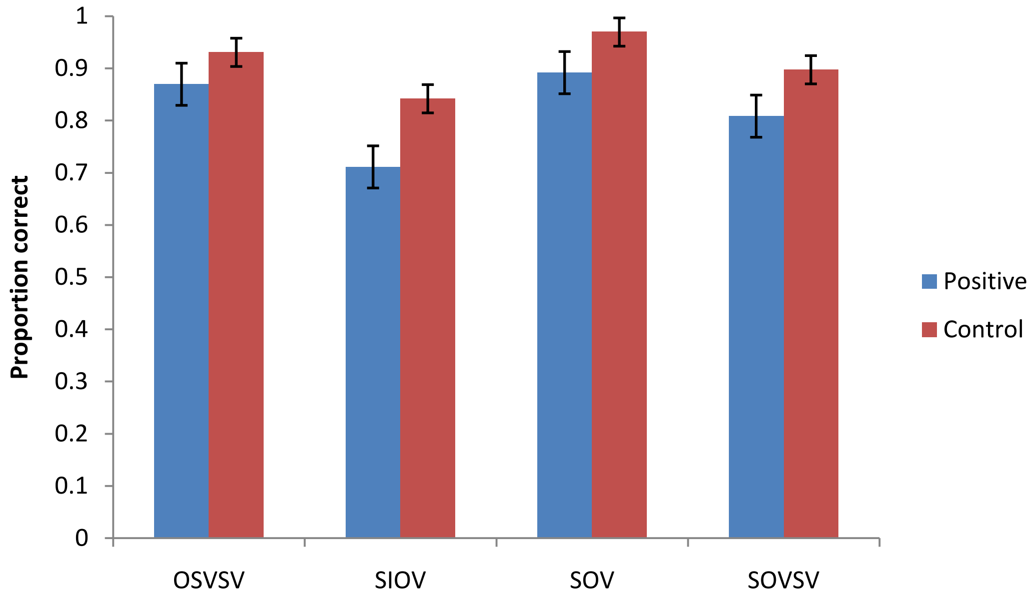
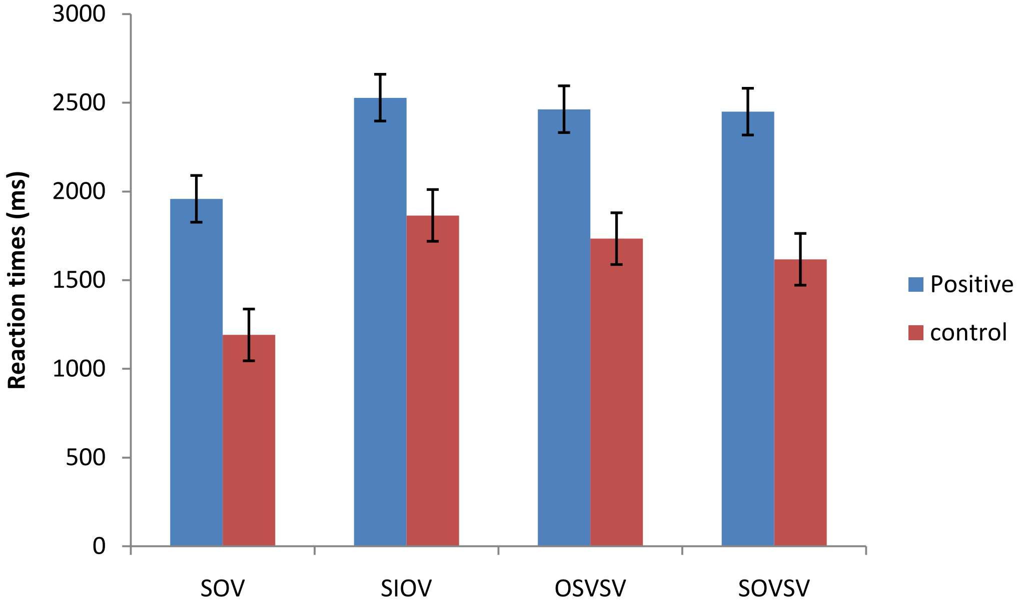


Figure 2



Proportion correct
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
OSVSV
SIOV
SOV
SOVSV
Positive
Control

Figure 3



3000
2500
2000
1500
1000
500
0
Reaction times (ms)
SOV
SIOV
OSVSV
SOVSV
Positive
control

Structure	Examples
SV	Horse-ga when fell?
SOV	Pilot-ga that runway-o saw
SIOV	Student-ga dog-ni what-o offered?
S when what-o V?	Bill-ga when what-o sang?
S who-ni what-o V?	That doctor-ga who-ni what-o showed?
S [SOV]V	John-ga angrily Mary-ga that ring-o lost that said.
OS[SV]V	That disease-o vet-ga cow-ga have that declared.

Table 2

Click here to access/download;Table;Table 2.xlsx

Simple sentence	SOV	a. Chinese: 男孩打碎了玻璃杯。
		b. Japanese:男の子はグラスを割った
		c. Stimulus:男孩は玻璃杯を打碎了
	SIOV	a. Chinese: 老人给了乞丐钱。
		b. Japanese:年寄りは乞食にお金を与えました
		c. Stimulus:老人は乞丐に钱を给
Complex sentence	[SOV]SV	a. Chinese: 小明说弟弟打碎了花瓶。
		b. Japanese:弟は花瓶を壊したと小明は述べました
		c. Stimulus:弟弟は花瓶を打碎了小明は说
	[OSV]SV	a. Chinese: 目击者说警察抓住了罪犯。
		b. Japanese:犯罪者を警察は捕まえたと目撃者は述べました
		c. Stimulus:罪犯を警察は抓住了目击者は说

Name of Material/Equipment	Company	Catalog Number	Comments/Description
E-prime	PST	2.0.8.22	Stimulus presentation software
Computer	N/A	N/A	Used to present stimuli and record subjects' responses
Self-Assessment Manikin (SAM)	N/A	N/A	Used to assess subjects' affective states. From Lang (19[illegible]

80)[29]

Dear Editor and Reviewers,

Thank you for giving us the chance to revise the paper. We have revised the paper in response to the extensive and insightful editorial and reviewer comments. The problems pointed out by the editor and reviewers have all been addressed. Below, we would like to outline our responses to these comments.

Editorial comments

General:

1. Please take this opportunity to thoroughly proofread the manuscript to ensure that there are no spelling or grammar issues.

Authors' response: Thank you. We have proofread the manuscript carefully and thoroughly. The spelling and grammar errors have been corrected.

2. Please include at least 6 key words or phrases.

Authors' response: We have provided six key words in the revised manuscript.

3. JoVE cannot publish manuscripts containing commercial language. This includes trademark symbols (™), registered symbols (®), and company names before an instrument or reagent. Please limit the use of commercial language from your manuscript and use generic terms instead. All commercial products should be sufficiently referenced in the Table of Materials and Reagents.
For example: E-Prime

Authors' response: We have replaced the word "E-prime" with "stimulus presentation software" in the revised manuscript. Apart from this, the manuscript did not contain trade mark symbols or registered symbols. E-prime has been referenced in the *Table of Materials.*

Protocol:

1. For each protocol step, please ensure you answer the "how" question, i.e., how is the step performed? Alternatively, add references to published material specifying how to perform the protocol action. If revisions cause a step to have more than 2-3 actions and 4 sentences per step, please split into separate steps or sub-steps.

Authors' response: Thank you. We have followed the editor's instructions to add more specific information regarding how the steps are performed. The revised protocol is more elaborate and detailed. The references to published materials have also been added.

Specific Protocol steps:

1. 1: Please provide, if possible, a sample E-prime script as supplementary information (or otherwise make available).

Authors' response: Thank you. We have uploaded the sample E-prime script as supplemental coding information.

Figures:
1. Please remove figure titles from the figures themselves.

Authors' response: We have removed the titles from the figures.

2. Figure 1: Please explain what exactly 'Time 1' etc. mean in the legend (or use more descriptive labels).

Authors' response: We have replaced 'Time 1', 'Time 2' and 'Time 3' with more descriptive labels. The revised labels are 'Before induction', 'After induction' and 'After training'.

Table of Materials:
1. Please ensure the Table of Materials has information on all materials and equipment used, especially those mentioned in the Protocol.

Authors' response: The Table of Materials has included all materials and equipment used in this study.

Reviewers' comments

Reviewer #1:
Manuscript Summary:
This study examines the impact of positive emotion on grammar learning using a semi-artificial language. While the research question is fairly novel and the semi-artificial language paradigm is commendable, there are significant concerns that should be addressed before this manuscript is suitable for publication.

Authors' response: Thank you. We have followed the reviewer's suggestions to revise the manuscript. All the problems identified by the reviewer have been addressed. Below you can find our specific responses to these concerns.

Major Concerns:
One of the main issues with the manuscript in its current state is that the methods sections reads as an instruction guide for lab member rather than a narrative of the methods. Critically, it lacks information on the participants and aspects of the experimental stimuli and procedure. Regarding participants, the following information is needed, at minimum: the number of participants per group, age and education level, Japanese proficiency (and how that was assessed), and whether the groups differed on any demographic variables.

Authors' response: Thank you. We agree that specific information about the participants need to be specified in the manuscript. In the revised manuscript, we added the required information in the discussion section. Specifically, the following information was provided:

"For this purpose, two groups of participants were recruited to participate in the experiment, including a positive-emotion group (15 female, M_{age}= 20.20, age range: 18-27) and a control group (16 female, M_{age}= 20.33, age range: 18-26). Each group consisted of thirty participants. The two groups did not differ in age, $t(58) = -.215$, $p = .831$, or years of education, $t(58) = -.830$, $p = .410$. None of them reported to have learned Japanese before." (Line 423-428)

Regarding the methods, at minimum, the following needs to be explained in greater depth: the SAM pictorial rating scale, for how long did the experimental group listen to the music (during the grammar learning task?), how the music was selected and validated as positive, what the control group did, a description of the grammatical structures learned and tested, more on how the stimuli were designed and counterbalanced or controlled for lexical variables across stimulus types. An accurate review of this manuscript's methods cannot be made until these issues are addressed.

Authors' response: We agree and have added more information about the SAM pictorial rating scale (line 248-251). We also specified the length of time participants listened to the music (line 254), and how a pilot study was implemented to validate the music (line 256-262). We added the information regarding how the experimental sentences were designed and counterbalanced and how we controlled the lexical variables (line 196-202, 205-207, 213-214).

The introduction nicely lays out the benefits of the semi-artificial language paradigm. However, prior to that, the first paragraph briefly mentions that there have been a few studies on emotion and other aspects of language processing. It would be informative to state the direction of the effect - whether emotion (and positive or negative) helped or hindered other aspects of language learning.

Authors' response: We agree and have added more information to specify the effect of emotion identified in previous studies. The following information has been added in the revised manuscript:

"Several prior studies have explored the effect of induced emotions on word production or text comprehension[2,3], and have consistently found that emotion had crucial influence on the two language processes. For example, Egidi and Caramazza found that positive emotion increased sensitivity to inconsistency in text comprehension in the brain areas specific for inconsistency detection, whereas negative emotion increased the sensitivity to inconsistency in less specific areas[2]. Hinojosa et al. examined the effect of induced mood on word production, and discovered that negative mood impaired the retrieval of phonological information during word production[3]. In spite of the evidence showing that emotions have a marked impact on text comprehension and word production, it is still not clear whether emotions affect grammar learning, one of the essential aspects of language learning. The present study aimed at exploring the effect of learners' emotional states on grammar learning." (Line 50-62)

The section header 'Representative Results' indicates these are not the results of the full group. Simply "Results" would be more helpful. Overall, the results indicate that positive *emotion lead to poorer performance (accuracy and reaction time) on the grammar learning task. First, it is not clear whether the initial ANOVAs on the accuracy and reaction time analyses include a factor of grammatical structure, or whether the results on individual structure represent follow-up analyses. If the latter, t-tests would be more appropriate than an ANOVA. A data analysis section at the end of the methods section would clarify some of these issues. Further, based on the graphs, it does not appear that emotion had as significant an effect on accuracy as indicated by the statistics. Perhaps using standard error rather than standard deviation would more clearly show a difference between the conditions. As it is, only the SIOV visually depicts a significant difference*.

Authors' response: Thank you. We have followed the reviewer's instruction to remove the word "representative" from the section header. We had added a data analysis section to clarify how data was analyzed in this study. We agree with the reviewer that the statistical approach used in the analysis was not very appropriate. In the revised manuscript, we reanalyzed the data using ANOVA with both emotion group and sentence type as predictors and performance variable (accuracy or RTs) as dependent variable. After reanalysis, we updated the results in the Results Section (line 365-378, 384-397). We also followed the reviewer's suggestion to add a data analysis section in the protocol (line 324-334). In this section, we provided the information about how we analyzed the data. As for Figure 2, we have updated it by using standard error instead. The revised figure clearly showed a significant difference between conditions in all sentence structures.

The interpretation of results is fine, though could include additional information. Further discussion of whether the participants were actually using inductive or deductive processing would be helpful. For example, how would the two approaches affect this task in particular? Moreover, the grammar manipulation concerns word order. Speculation on why emotion would impact this processing would be informative. Finally, the second paragraph of the discussion states that the individuals in the experimental group were happier than those in the control group, but there was no mention in the methods (or results) of a happiness rating.

Authors' response:
We agree and have added the required information. First, we explained how inductive and deductive processing may affect the experimental task. The following information was provided in the Discussion section: "Inductive processing involves the careful consideration of detailed information and the use of analytical strategies to process information. Deductive processing, on the other hand, involves the use of heuristic strategies which features a strong reliance on previous experience to speed up the problem-solving process. As grammar learning is a process which requires the consideration of the relationships between different linguistic units and the extraction of the rules governing these relationships, inductive processing is a more facilitative processing style than deductive processing." (line 446-452)

Second, we specified the reason why emotion would influence the processing of word order. The following information was added to the Discussion section: "In the present study, we manipulated the word order and case-marking of the experimental sentences, which are essential aspects of grammar. This learning task required participants to analyze and identify the relationships between different words in the sentences, and formed judgments about the legitimate order of the words in the sentences. Most importantly, these judgments have to be based on the careful observation and analysis of specific linguistic details such as syntactic categories or semantic roles. Therefore, word-order learning benefited more from inductive strategies and the corresponding bottom-up processing style." (line 453-460)

Finally, we added more information (line 346-347, 356-357) in the Results section to point out that the experimental group was significantly happier than the control group.

<u>Reviewer #2:</u>

> *This is a straightforward study presenting a protocol of an experimental paradigm that allows for studying the effects of induced positive mood on semi-artificial grammar learning. The protocol is correctly described and nicely accompanied by a set of experimental data that support the main claims and the validity of the paradigm, and the authors correctly introduce all the details to the readership in a direct and comprehensive manner. Nonetheless, there are three main issues that need to be dealt with in a revised version of the manuscript before a positive decision can be made, and I'll briefly mention them below.*

Authors' response: Thank you for your appreciation of our work. The three main issues pointed out by the reviewer have all been addressed in the revised manuscript. Below we listed our responses to these comments.

> *1) Emotion vs. mood. The authors argue about the potential effects of emotion on grammar learning, but they should acknowledge that they are testing the effect of artificially induced positive mood, which is not the same in essence. By reading the title of the study one could get the wrong impression that what the authors were testing here is the effect of learning emotionally loaded constructions (using high-arousal lexical forms, for instance), but they're doing a completely different thing here, and this should be clearly stated in the manuscript. Moreover, only induced positive mood is tested here, and the results may not necessarily hold the same for negative mood. This is also something to discuss in the study.*

Authors' response: We agree with the reviewer that it is necessary to clarify that we only investigated artificially induced positive emotion. Therefore, we have added more information in the Abstract, Introduction, Method, and Discussion sections to stress that we investigated the artificially induced emotions. In the limitation section, we added a statement to acknowledge that the findings from our study cannot be generalized to negative emotion. Specifically, the following sentences have been added to revised manuscript:
"Besides, as this research has only examined the effect of artificially induced positive emotion on grammar learning, the results may not necessarily hold the same for negative affective states. Further studies are needed to explore how negative affective states might influence foreign language learning using the semi-artificial language paradigm." (line 522-526)

2) Literature on emotion and mood. There are many high-impact studies from the field of affective neurolinguistics showing a strong relationship between emotion and language in multiple forms, and the article would clearly benefit from a comprehensive summary of these findings. This recent review article and the commentaries that followed it in the same journal could be of help for the authors: https://doi.org/10.1080/23273798.2019.1620957

Authors' response: Thank you. We followed the reviewer's suggestion to provide a more comprehensive review of the previous studies in the field of affective linguistics. We summarized how emotion can be related to language in various ways. The following literature review has been added to the Introduction section:

"Language and emotion are two primary components of human experience[4]. Their relationships have mostly been explored by studies in affective neurolinguistics. At the single word level, the studies have consistently found significant effects of emotional features such as arousal or valence on the processing of individual words[5,6,7]. Specifically, some studies have identified a significant advantage for positive words[5], and other studies have found an advantage for both positive and negative words[7]. Although some studies have reported an interaction between valence and arousal, a lack of significant interaction was reported in other studies[4]. The picture is more complicated at the level of combinatorial processing. Previous studies have explored the issues concerning the interaction between emotional content and syntactic or semantic unification processes during sentence comprehension. Emotional information has been found to exert different influence on the processing of gender or number features[4]. Besides, positive and negative emotion was connected with different agreement effects[4]. For instance, positive emotional features have found to facilitate number agreement processing, whereas negative emotional features inhibited number agreement processes[4]. At the semantic level, emotional features influenced semantic unification processes in both sentence and discourse contexts through the activation of a number of brain regions involved in single word processing and combinatorial semantic processes[4]. A review of previous literature indicated that most prior research has focused on the effects of emotional information on the comprehension of words, sentences and texts[8,9], or the neural basis of emotional effects on language production[10,11]. However, how individuals' affective states might influence language processing or learning has been relatively less researched." (Line 64-86)

3) Comparison between groups. The authors report interesting and suggestive differential effects between the two groups tested in their study, but there's a genuine problem in this protocol regarding the lack of a priori measures that ensure similar processing of grammaticality and of learning in the absence of any mood manipulation. So far, what we are presented with is a significant difference all across the board between two groups in the critical dependent measures, but no control measure was included to demonstrate that the two groups did not differ in basic aspects that were not controlled for and that could have biased their behavioral responses. Ideally, the protocol should also include a series of pre-test manipulations that allow for unambiguously demonstrating that the two groups judge and learn things similarly in the absence of mood induction.

Authors' response: We agree with the reviewer that this protocol should have included a priori measures to ensure the two groups had similar baseline performance. In our study, we only checked participants' learning ability by having them report their performance in a recent foreign language proficiency test. This might not be enough. In the revised manuscript, we added a Modifications and Troubleshooting section to acknowledge and address this problem. The following information has been provided:

"A major problem with this protocol is the lack of a priori measures that ensure similar processing of grammaticality and of learning in the absence of any emotion manipulation in the two groups. An ideal protocol should include a series of pre-test manipulations that allow for unambiguously demonstrating that the two groups judge and learn things similarly in the absence of emotion induction. For example, we may administer a grammaticality judgment task and a word-order learning task using another foreign language, and compare the performance of the two groups. They should only be allowed to proceed to the experiment if no significant difference is found. The results of this study would be more convincing if we were able to demonstrate, prior to the experiment, that the two groups did not differ in basic aspects that could have biased their behavioral responses. This is a step that has been ignored in our protocol and should be given sufficient attention in future studies." (line 502-516)

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Supplemental Coding Files
Sample coding files.txt