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Examining Rule Extraction from Sign-Language Like Gestures in Adults

Elizabeth Joy T. Sodimu
University of Illinois Chicago

Elizabeth Joy T. Sodimu graduated *summa cum laude* from the University of Illinois Chicago in May 2023 with a Bachelor of Science degree in neuroscience and a minor in professional writing. She worked at her college's writing center throughout her undergraduate years while staying involved in various student organizations. Following her bachelor's degree, Elizabeth intends to pursue a Doctor of Medicine degree to become a geriatrician, because she is dedicated to working to improve care of the elderly population. In her free time, she enjoys spending time with her friends and family, crocheting, writing, and reading. Elizabeth would especially like to thank Dr. Kara Morgan-Short for her mentorship and support throughout this project.

Abstract

Previous research has explored different aspects of adult language learning, including sign-language learning, which relies on visuospatial modes of expression. Studies with infants have shown rule learning in visuospatial modes, and research has also found that adults can extract rules from various types of audiovisual sequences. However, research has yet to examine rule-learning from visuospatial signs for sign-like gestures in adults. The current study examines adults' abilities to learn rules from sign-like gestures. Participants are first familiarized with visuospatial sequences following an ABB, AAB, or ABA rule. In a subsequent testing phase, they are told that the sequences followed an unspecified rule and are asked to discriminate between sequences that do or do not follow the rule. Results show above-chance test performance for all conditions, with no differences across the conditions. These findings indicate that participants can learn rules from sign language-like gestures, and that this ability is not specialized to a certain rule. Overall, the results suggest that adults may be able to extract rules from sign languages like American Sign Language (ASL) and moves toward contributing to the dismantling of the stigma that adults cannot learn additional languages, even if they include modality shifts.

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The population of individuals who use sign language globally is large in number, although their reasons for using sign language may vary. Many of these individuals are Deaf and require sign language as their primary source of communication, although not all Deaf individuals use sign language. Also, among this population are hearing individuals who are learning a sign language as an additional language for their own interests or to communicate with Deaf individuals around them. For these second-language learners of sign language, there is often a required shift from auditory/visual modes of communication to visual/motor modes, which can be a source of difficulty in learning. Due to these difficulties, there is a need to examine the potential of adults to learn sign language as an additional language, and to suggest what methods will make this learning more efficient.

Whether conscious or unconscious, rules and patterns play a role in the language learning process. For example, in English, sentences follow the subject-verb-object (SVO) form, while other languages such as Korean follow the subject-object-verb (SOV) form. Infants may not be explicitly taught rules such as these, but research has shown they are able to extract rules from languages for which they have no prior experience (Berent et al., 2021). In adults, research has shown that for English-speaking learners of the Hebrew language, being able to learn a statistically determined pattern predicts second-language literacy acquisition (Frost et al., 2013). Simply put, our ability to recognize rules and patterns can impact our overall ability to learn a language.

From previous research, we know that infants are generally capable of learning rules (Rabagliati et al., 2019), including rules from sign language and sign-like gestures (e.g., Berent et al., 2021; Rabagliati et al., 2012). However, there is not much research specific to rule learning in adults for sign language and sign-like gestures. The current study addresses this gap in the research, and thus aims to contribute to the literature about how adults can learn sign language as an additional language, with a focus on the ability to extract rules from sequences of sign-like gestures.

Rule Extraction from Sequences

Evidence from Infants

The ability of infants to extract rules from sign-like gestures has been demonstrated in several empirical studies (e.g., Rabagliati et al., 2012; Rabagliati et al., 2019). The more recent empirical and meta-analytical work by Rabagliati et al. (2019) has also demonstrated the role that different factors play in extracting rules. In their experimental study, Rabagliati et al. (2019) examined the roles of meaningfulness and repeated elements in the presented stimuli in 63 monolingual, English-learning seven-month-old infants with normal hearing and language development. Throughout three phases of this experiment—pre-exposure, habituation, and test—infants were shown videos with one or more actors using gestures based on ASL. These gestures were set to occur at a rate that would be considered linguistic. The individual gestures, referred to as "tokens," were either type "A" or type "B" and were used to make sequences following an ABB or ABA pattern for both the habituation and test trials. The experiment consisted of three learning conditions: (a) a control condition, (b) a condition in which infants were primed to view gestures as communicative and meaningful, and (c) a condition in which infants were primed to consider gestures to be non-communicative. Infants were randomly assigned to one of these three conditions, within which they were randomly assigned to be habituated to an ABB pattern, which included an immediately repeated token; or an ABA pattern, which did not include an immediately repeated token. Infants in the second and third conditions underwent a pre-exposure phase. In the communicative condition, one actor used the gesture to communicate with the other actor and the infant, and the other actor would respond verbally. In the non-communicative condition, both actors would produce the same sequence of gestures, but would face away from each other and the infant. The pre-exposure phase was followed by the habituation phase, where infants underwent up to 25 trials consisting of up to 16 sequences of videos with an actor who would produce gestures following either the ABB or the ABA pattern. A different set of gestures was used to form new ABB and ABA sequences for the test phase; these were presented by the same actor over eight trials. Rabagliati et al. (2019) found that there was significant learning observed when infants were primed to interpret sign-like gestures as communicative and meaningful, in comparison to infants who were primed to interpret them as non-communicative and not meaningful. The researchers also found no differences between the two habituation patterns, although previous research had found such differences (Rabagliati et al., 2012).

The empirical findings from Rabagliati et al. (2019) were consistent with findings from their meta-analysis, which examined, via p-curve analyses, the factors that moderate infant rule-learning based on previous research, as well as the strength of the evidence that was published concerning infant repetition rule-learning abilities. The results provided strong evidence that infants can learn abstract repetition rules. Infants were shown to learn abstract repetition patterns best from spoken stimuli, an advantage that was enhanced if it was meaningful to the infant. The Rabagliati et al. (2019) meta-analysis did not find evidence that patterns with immediate reduplication (repetition) (e.g., ABB/AAB) were easier to learn, in comparison to those with no immediate reduplication (ABA). However, they found that there was some evidence of a recency effect in learning, as ABB patterns were easier to learn than AAB patterns. Overall, this study demonstrates the potential for infant rule learning from sign-language-like gestures, although the contributing factors to such learning have not been conclusively determined.

The research done by Berent et al. (2021) extends the work of Rabagliati et al. (2012) and Rabagliati et al. (2019), finding that infants are able to extract rules from linguistic signs, and that the finding that infants have differential responses to rules in signs reflects rule learning in speech. There is a sensitivity to rules that is tuned to the linguistic status of the stimuli (linguistic vs. nonlinguistic) (Berent et al., 2021). This finding points to the idea that infants have an amodal system for rule learning that allows them to extract rules across modalities.

In sum, existing literature has demonstrated that infants can learn rules from languages that use auditory (e.g., speech) and visual (e.g., sign-like and sign) modalities. This ability is strongest when looking at abstract repetition rules from speech, but infants are also able to extract abstract rules from nonverbal gestures that are communicative.

Evidence from Adults

Similar to the findings reported above, showing that infants can extract rules from both signed and spoken languages, research has also shown that adults can extract rules from spoken language (audiovisual) sequences. This was the case in Endress et al. (2005), which had the goal of comparing unitary vs. piecemeal views about rule-based generalizations where participants need to differentiate the abstract symbolic structures from a sequence of stimuli. The study also aimed to demonstrate that some types of rule-based learning are constrained by where in the stimulus sequence critical regularities occur. Lastly, it aimed to explore the possibility that rule-based learning utilizes fundamental parts of the mind, for which only certain types of regularities stand out. In this study, there were three experiments performed, each with its own subparts.

Experiment one of the Endress et al. (2005) study explored whether participants could generalize repetition-based structures, regardless of where the repetition occurs in a sequence of syllables. It included 40 participants between the ages of 19 and 37, all of whom were native speakers of Italian. Sequences in this experiment were of two types: (a) edge repetitions, where a syllable was repeated at the end of the sequence (e.g., ABCDEFF), or (b) internal repetitions, where a syllable was repeated in the middle of the sequence (e.g., ABCDDEF). Participants were first familiarized with sequences containing an edge or internal repetition and were subsequently asked to identify if new sequences they were shown contained the same repetitions they were shown earlier. Researchers observed that the participants were able to generalize repetition-based structures for edge repetitions, but not for internal repetitions. Following experiment one, Endress et al. (2005) conducted two experiments to rule out the possibility of the results in experiment one being explained by familiarization or participant difficulty with encoding items containing internal repetitions. Based on the results of these experiments, they concluded (a) that familiarization did not explain the observed results in experiment one, and (b) that there may be a primitive processing system that is better able to recognize edge-based repetitions.

A study conducted by de Diego-Balaguer et al. (2011) also examined rule extraction, but by looking at streams of artificial languages. Researchers examined oscillatory brain activity to understand the neural mechanisms underlying word and rule learning in the early stages of exposure to a new language. Participants listened to “streams” of four artificial languages consisting of trisyllabic words over two experiments in which EEGs were recorded. In the first experiment, the length of the streams was the same for all participants, while in the second experiment there were two groups with varied stream lengths. In both experiments, participants were tested on word acquisition and rule learning. “Good learners,” those participants with the highest scores on the rule learning test, were more focused on structural information. “Poor learners” were more focused on memorizing the whole word. Through a repeated measures analysis of variance (ANOVA), de Deigo-Balaguer et al. found that good learners improved their rule-learning performance over time, but poor learners showed a decrease in rule-learning performance. The EEG data reflected word learning as an increased coherence in the theta band/wave, and rule learning was associated with an increase in activation of frontal and temporal areas. De Diego-Balaguer et al. concluded that there are likely different roles of attention and memory processes in the process of learning words and rules.

It has also been found that rule learning can be constrained by the presence of familiar objects (Orticio and Christie, 2020). In the two-part study conducted by Orticio and Christie, English-speaking adults were shown sequences of syllables (experiment one) and sequences of shapes (experiment two). Following a familiarization phase, participants were asked to choose either between sequences that followed the familiarization rule or a new rule (control condition), or between those that followed the familiar rule or a new rule with a familiar object (object match condition). For example, if the participant was familiarized with an ABB string, some of which contained the syllable “de,” an object match condition trial could have them choose between “ga ti ti” (familiar rule, ABB) and “li de li” (novel rule, ABA). Orticio & Christie found that adults can extract structural rules from two-minute exposure (the length of the familiarization trials) for both syllables and shapes, and that the presence of a familiar object could divert participants’ attention from the familiar rule.

As evidenced by the aforementioned studies, adults can extract rules from different stimuli. From these studies, it is of note that adults can extract rules from the auditory modality, as was shown in de Diego-Balaguer et al. (2011), Endress et al. (2005), and Orticio & Christie (2020). The question remains open, however, regarding whether adults can extract rules from signs or sign-like gestures in the visual modality.

Research has considered adult sign language learning in several domains, e.g., fingerspelling (Geer & Kean, 2018), word learning (Marshall & Morgan, 2015), and grammar learning (Ortega & Morgan, 2015; Gimeno-Martinez et al., 2019; Boers-Visker & Pfau, 2020), among others. However, to our knowledge, no study has examined rule learning in adults from sign-like gestures.

The Current Study

To expand on current research, we proposed that the ability of adults to extract rules from sign-like gestures could be examined using the protocol from Rabagliati et al. (2019) as a means of informing the potential ability of adults to extract rules from sign language itself. However, because in the present experiment we are studying this ability in adults rather than children, a method different from habituation, the strategy used by Rabagliati et al. (2019), is needed to determine whether rules can be successfully extracted. Rather, adults can undergo a familiarization phase where they are tasked with memorizing sequences of sign-like gestures that follow a rule to the best of their ability, similarly to the procedure described by Endress et al. (2005). However, in this familiarization phase, adults are not told about the presence of the rule. To examine rule extraction, participants undergo a testing phase where they see a mix of sequences of sign-like gestures that follow the rule-based pattern used in the sequences that were viewed in training, as well as sequences that do not follow the pattern. Each participant is instructed to indicate whether the sequences follow the familiarization rule. If the participant's choices match the correct response for each sequence of gestures, then it can be concluded that they are able to extract the grammar rule from the sign-like gestures. Through numerous studies, rule extraction has been observed in adults for various kinds of sequences, such as those mentioned above. This phase of our study makes the case that they might be able to extract rules from sign-like gestures. The ability to extract rules from sign-like gestures is present in infants and may be present in adults as well, although it may present differently.

Furthermore, following Rabagliati et al. (2019), it is of interest whether adults can learn different types of sequences. For example, there is some evidence that infants learn ABB sequences better than AAB sequences or ABA sequences. A consideration of AAB and ABB vs. ABA will show whether the salience of a repetition plays a role in rule learning. Looking at AAB vs. ABB will show whether the recency effect has any bearing on rule learning: namely, the fact that the consecutive repetition of gestures in the ABB condition is at the end of the sequence, rather than the beginning as it is in the AAB condition. By looking at rule learning for different sequences, such as those that consist of sign-like gestures, in adults, we examine the potential of adults to extract rules from sign-like gestures and sign languages, which could have critical implications for learners of sign language as an additional language. More specifically, we investigate the following research questions:

RQ1: Can adults extract rules from sign-like gestures?

RQ2: If yes, are these abilities specialized to certain rules?

Methods

Participants

Fifty-four participants over the age of 18 were recruited for and completed the study. Fifty participants (mean age = 18.5; age range = 18-21; 38 female) were included in the final analysis[1]. Participants were all native or fluent speakers of English, with varied experience with additional languages (mean number of additional languages = 1.98, range = 1–4). No participant was a fluent speaker of ASL, although some had limited experience with the language (n = 9). Participants were recruited via a psychology department's subject pool at a large university in the Midwestern United States and were pseudo-randomly assigned to one of the three familiarization conditions (AAB, ABB, or ABA). All participants completed informed consent forms in accordance with the requirements of the institutional review board.

Materials

The stimuli for this experiment were adopted from the Rabagliati et al. (2019) study and consisted of four-second pre-recorded videos showing a single actor using American Sign Language (ASL) handshapes. These are referred to as "sign-like gestures," because although they are handshapes that are used in ASL, they are not used to form any meaningful communication in this experiment, just patterns. Rabagliati et al. (2019) reported similar timing for all the videos, with the actor taking 1.33s for each gesture (approximately 0.66s to raise the hand for a gesture and 0.66s to lower it). The gestures produced by the actor were positioned above their right shoulder to allow for a clear view of the gestures. Video stimuli were compiled into their appropriate conditions using Psychopy (Peirce et al., 2019).

Apart from the practicality of using previously created stimuli, the stimuli from Rabagliati et al. (2019) were selected for this study in order to build on prior research more directly and to determine that differences between the findings in this study and previous research were not due to the stimuli themselves. Additionally, the use of sign-like gestures allows for the control of various factors (e.g., facial expressions or location) in ASL that might have been a confound in the current research. Note, however, that results from this study would need to be confirmed with research using natural sign language.

Familiarization-phase materials

For the familiarization phase, the current study adopted the gesture videos from the habituation phase of Rabagliati et al. (2019). As in Rabagliati et al. (2019), ASL gestures/handshapes were labeled as either A tokens (specifically, the tokens labeled *Bent-Five*, *U*, *1-I*, and *L*) or B tokens (the tokens labeled *O*,

1 Four outliers were identified using Jamovi, a statistical software program, and removed from the final testing analysis.

L-I, *B*, and *Six*), and these handshapes were used to make sequences that either followed the pattern AAB, ABB, or ABA. In total, there were 48 sequences formed: 16 AAB, 16 ABB, and 16 ABA sequences. From these 48 sequences, 32 familiarization trials were created, consisting of two sequences that either matched or did not match. Thus, for the ABA condition, half of the trials were "matches," containing two identical ABA sequences. The other half of the trials were "nonmatches" that contained two nonidentical ABA sequences (Figure 1). Match and nonmatch trials were presented in a pseudo-randomized order.

Testing-phase materials

For the test phase, the current study again adopted the test phase gesture videos from the Rabagliati et al. (2019) study, including two new A tokens (*Five*, *V)*, and two new B tokens (*H*, *I*). As stated in the Rabagliati et al. (2019) paper, these four tokens were used to create four novel random AAB, ABB, and ABA sequences. Because the test phase consisted of 16 trials (half of which did not follow the familiarization rule), the trials in the test phase were created as follows: For the ABA condition, four of the sequences that followed the familiarization rule were the novel sequences, and four were from the familiarization phase, selected at random. The other eight sequences were selected at random out of the 16 AAB and 16 ABA sequences, four coming from the novel sequences and four coming from sequences used in the familiarization phase. Thus, there were 16 trials for each condition of the testing phase, half of which followed the familiarization rule (half novel, half familiar), and half of which did not. The same process was used to arrange the stimuli for the other two rule conditions. As in the familiarization phase, trials were presented in a pseudo-randomized order.

Procedure

The current study was administered on a computer monitor, with a keyboard for participants to use for their responses. Participants sat directly in front of the monitor, with the keyboard and mouse in front of them on a table. The study procedure was adapted from Endress et al. (2005) but used sequences of sign-like gestures rather than sequences of spoken syllables. First, participants underwent the familiarization phase. Instructions for this phase were read aloud to participants (see Appendix). Participants in the ABA condition of the familiarization phase completed 32 trials, each of which contained two videos shown in sequence. The sequences in the videos followed the ABA rule only and were separated within each trial by a two-second pause. After each video sequence was shown, participants viewed a screen where they could indicate if the sequences that they saw were identical (Y) or not (N). Response selection marked the end of the trial and was followed by a two-second delay before the next trial began, in accordance with the procedure from Endress et al. (2005). The same procedure was followed for participants in the AAB and ABB conditions.

Immediately following the familiarization phase was the testing phase, which began in a similar manner with the instructions being read aloud to participants (see Appendix). This phase consisted of 16 trials, each of which contained one video. Each video was followed by a response screen, where participants could indicate if the trials were rule-following (Y) or not (N). Response selection marked the end of each trial and was followed by a two-second delay before the beginning of the next trial. This procedure was used for all three testing conditions.

Finally, participants completed a questionnaire, which first asked participants if they noticed any rules or patterns during the familiarization phase of the experiment. It also inquired about the language background of participants, including the number of languages that they knew, their exposure to those languages, and the extent to which they were able to read, speak, write, and understand them.

Results

Familiarization

The main objective of the familiarization phase was to ensure that learners paid attention to the task and thus had the potential to learn. To determine this, we considered performance on this task by calculating the mean accuracy for each condition (see Table 1 and Figure 2). For all three groups, the results indicate a high mean overall, although accuracy varied among the participants. The groups performed above chance, as indicated by 95% confidence intervals (CIs) above 0.50 (chance level) (Cumming, 2014). Also, the 95% CIs of the three groups overlapped, indicating that there was no significant difference in their performance. The above-chance performance of all three groups indicated that they all had the potential to learn.

Testing

To answer the research questions, we consider the results from the testing task (see Table 2 and Figure 3), once again considering mean accuracies for each group. First, regarding RQ1 (Can adults extract rules from sign language-like gestures?), 95% CIs around mean accuracies for each group were examined. For the AAB, ABA, and ABB groups, the results indicate that the mean accuracies were 90%, 97%, and 87%, respectively. All three groups performed above chance on the testing task as indicated by the 95% CIs above 0.50 (chance level), which means that they all were able to learn the rules. However, there was slightly more variability in the mean accuracies of the AAB and ABB groups in comparison to the ABA group. Second, regarding RQ2 (If yes, is this ability specialized to certain rules?), means and 95% CIs were examined for (non-) overlap between groups. The means showed that the ABA group performed the best, almost at ceiling. The AAB group was somewhat less accurate, followed by the ABB group, with the lowest score. However, the results showed that the 95% CIs for all three groups overlapped, indicating that there was no significant difference between the groups, although the AAB and ABA groups just barely overlapped.[2]

A post-hoc analysis of the debriefing questionnaire was conducted to analyze participant awareness of the rules assigned to them in the first part of the experiment. Participants were asked if they noticed a rule in the familiarization section, and if they had, to describe the rule that they perceived. Their responses were organized and coded as "correct rule" (participant correctly recognized their assigned rule, "incorrect rule" (participant noticed a rule, but it was not the correct one), or "no rule" (the response given by the participant was not relevant to the question asked). The amount of "correct rule" responses for each condition were totaled (Table 3), and the analysis revealed that participants seemed to have more difficulty verbalizing awareness of the ABB rule (see Appendix).

Discussion

The current study examined whether or not adults can extract rules from sign-like gestures, and if such rule extraction is specialized for certain rules over others. The results from the study showed that adults were able to learn from sign language-like gestures. To our knowledge, this is the first demonstration of adults learning from sign language-like gestures, adding to previous literature that demonstrates adult learning from audiovisual stimuli (Endress et al., 2005; de Diego-Balaguer et al., 2011; Orticio & Christie, 2020). The ability for rule extraction from sign language-like gestures has previously been observed in children, as was the case in the Rabagliati et al. (2019) study.

One of the differences between findings from previous research with infants (Berent et al., 2021; Rabagliati et al., 2012; Rabagliati et al., 2019) and this study is that the adults who participated in the current study did not appear to show any clear rule specialization. Adults were largely able to extract rules irrespective of the gesture pattern (AAB, ABB, or ABA). If adults are able to extract rules from all types of sequences of sign-like gestures, it may be the case that they can extract rules from sign languages like ASL, and that the presence of rules may facilitate (or at least play a role in) the learning of a visuospatial language like ASL.

Although there was no rule specialization apparent in the study, it is interesting to note that participants performed lowest for the ABB rule (although this was not a statistically significant result). In addition, they seemed to have difficulty verbalizing awareness of this rule, as the post-hoc analysis revealed. Initially we expected this condition to be one that participants would have clearer

2 The overlap of these two groups is due to rounding to three decimal places. The upper bound of the 95% CI for the AAB group is 0.947, while the lower bound of the ABA group is 0.950.

awareness of, because the duplicate pattern would be salient and the two gestures being at the end of the sequence should have had the advantage of being recent, as was suggested by the infant literature (Johnson et al., 2009; Rabagliati et al., 2012). Overall, though, adults in our study—even in in the ABB condition—showed a high degree of accuracy in learning rules.

As mentioned above, learning a sign language, for an individual with a spoken native language, requires a shift in modality. Humans naturally look for patterns when learning. By exploring the rules and patterns that are easy to learn for a sign language like ASL, we can find ways to make the learning process more efficient.

Limitations and Future Directions

These results should be considered alongside the study limitations. One limitation of the current study is that the age range for the study was narrow. Due to the setting of this study on a college campus, a sample of convenience was taken, in which all participants were between the ages of 18 to 21. To make more robust conclusions about the abilities of adults, it would be beneficial to expand the age range of the study and sample from the general adult population. Research has shown that there are general differences between cognitive abilities for young vs. older adults (Fraundorf et al., 2019; Mutter & Plumlee, 2014; Racine et al., 2006), so having samples of older adults would provide a more comprehensive view of adult rule extraction from sign-language like gestures. However, we have established in this study that young adults can extract rules from sign-language-like gestures. The present study is also limited in that we were not able to make any direct conclusions about sign language, as this study used sign-language-like gestures, not sentences or phrases from a sign language like ASL. As such, it would be interesting to consider adult rule learning from ASL with the same research question.

For future research, a follow-up study should be conducted to further examine whether learning the ABB sequence is more challenging for adults, and if so, why. Also, it would be interesting to consider whether participant ability to verbalize rule awareness correlates with the process of learning a sign language. As this study was also done within one location, a further application of this study could consider rule extraction from a sign language across regions. Sign languages like ASL have many dialects across the United States, and it would be interesting to see if differences in dialect also lead to differences in rule learning. Lastly, a future application of this study could examine rule extraction from sign languages in the context of an adult sign-language-learning classroom, to see which patterns (if any) adults actively use as they learn sign languages, and if such patterns can be implemented into an improved pedagogy for adult sign language learners.

Conclusion

This study sought to examine the ability of adults to extract rules from sequences of gestures that mimic ASL and to consider what this implies about the ability of adults to learn a sign language as an additional language. Based on the results, it begins to appear that adults can extract rules from sign-language-like gestures, and this ability may not be specialized to a certain rule. If adults can extract rules from a sequence of sign-language-like gestures, it may be the case that they can also extract certain rules from sequences of a sign language (for example, ASL). Overall, this study serves to (a) add to the body of research on sign language learning by exploring it in the context of adult learning and (b) to contribute to the dismantling of the stigma that adults are unable to learn additional languages, even if they include modality shifts.

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Table 1

Descriptive statistics for mean participant accuracy in all conditions.

	AAB (*n* = 17)	ABA (*n* = 17)	ABB (*n* = 15)
Mean	0.98	0.98	0.97
95% CI	[0.96, 0.99]	[0.97, 1.00]	[0.94, 0.99]
Standard Deviation	0.03	0.033	0.046

Table 2

Descriptive statistics for mean participant accuracy in all conditions.

	AAB (n = 18)	ABA (n = 17)	ABB (n = 15)
Mean	0.90	0.97	0.87
95% CI	[0.86, 0.95]	[0.95, 0.99]	[0.78, 0.96]
Standard Deviation	0.09	0.04	0.16

Table 3

Total correct rule responses for all conditions.

	AAB (n = 18)	ABA (n = 17)	ABB (n = 15)
Correct Rule Responses	15	17	8

Figure 1

Still frames of (a) match and (b) nonmatch ABA sequences, created based on material available at https://osf.io/5k3vw/ *(Rabagliati et al., 2018).*

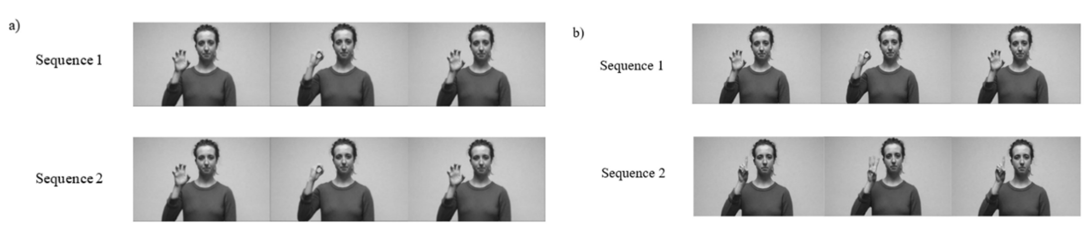


Figure 2

Box plot representing mean participant accuracy for familiarization by condition.

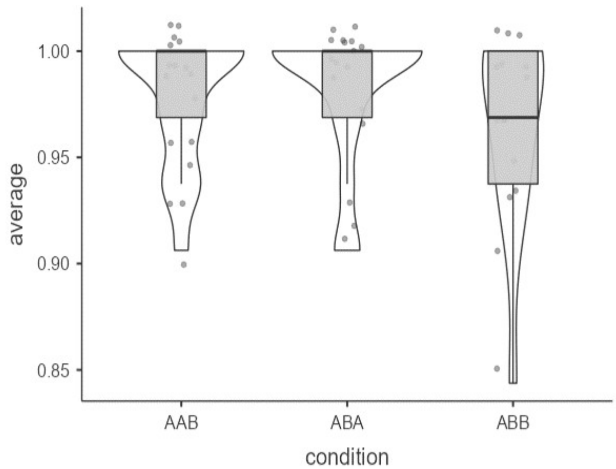
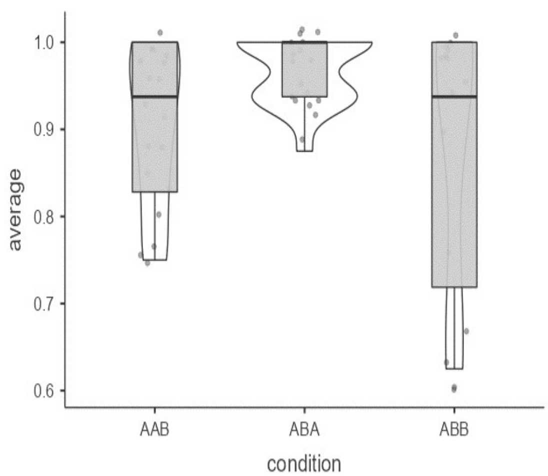


Figure 3

Box plot representing mean participant accuracy for testing by condition.



Appendix

Instructions from the familiarization phase

This experiment consists of two parts. In the first part, you are going to see 32 trials of 2 three-gesture sequences consisting of sign-like gestures. Try to memorize the first sequence.
After having seen the first sequence, you should decide whether or not the second sequence was identical to the first one. Press "Y" if you think that the second sequence was identical to the first one. Press "N" if you think that the second sequence was not identical to the first one. If you are unsure, trust your intuition.

Instructions from the testing phase

The sequences that you have memorized in the first part contained a regularity (rule). Now you are going to see new three-gesture sequences. Half of the sequences contain the same regularity as the sequences you have memorized in the first part.
Press "Y" if you think that a sequence contains the same regularity as the sequences you have already memorized. Press "N" if you think that a sequence does not contain the same regularity as the sequences you have already memorized. If you are unsure, trust your intuition.

Sample responses from background questionnaire

Question

Did you notice any rules or patterns while you were completing part 1 of this study? (If yes, please elaborate on what you noticed.)

AAB samples
Aware—Yes, the pattern was to have the same 2 signs in a row and end in a different sign.
Unaware—Yes she [the actor] would repeat certain hand motions, and those hand motions helped me memorize for later.

ABA samples
All participants in this condition indicated rule awareness in their responses.
Aware—Yes, the first and last sign would always be the same. The second sign in the sequence would always be different.

ABB samples
Aware—One of the patterns I noticed is that the first hand gesture was only shown once and the second two were always the same.
Unaware—Yes some patterns I noticed were some signs kept repeating while some stayed the same.