Analysis of sequential patterns of stereotypy and variability in human conditional discrimination tasks [1]

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Abstract

In order to evaluate whether reinforce responses of repetition or varied did produce sequential patterns in humans, the frequency distributions of the sequences performed under a conditional discrimination paradigm were analyzed. To make such analysis, data were taken from a previous study in which children and undergraduate students were exposed to tasks of repetition or variability using a matching-to-sample procedure. On the stereotypy task the same choice made in the previous trial was reinforced, while in the variability task a response was considered correct when was distinct from the choice made in the previous trial. Those authors reported that the children and undergraduates in their study obtained the maximum number of correct responses on stereotypy tasks, while on the variability tasks the number of correct responses was lower and the maximum number of correct responses was rarely reached. Another finding was that sequential effects by the order of the tasks were identified, such that when stereotypy was preceded by variability performance was not optimal, though when the order of the tasks was reversed, the opposite result was found. However, one aspect omitted in that study was analyzing possible sequences of responses on both tasks. Once performed that analysis revealed two sequence patterns: a) in the stereotypy condition one pattern showed persistence to respond to one specific sequence; and, b) in the variability condition, the frequency of sequences was distributed uniformly among the six variable sequences options. We discuss whether the matching-to-sample procedure, in addition to producing stereotypy, is useful for producing varied responses or simply generates an alternation of responses that switch from one option to another.

Keywords: *sequential patterns, matching-to-sample, stereotypy, variability, homogeneous, heterogeneous, humans.*

Resumen

Con la finalidad de evaluar si se establecieron patrones secuenciales de respuestas repetitivas o variadas en humanos, las distribuciones de frecuencia de secuencias emitidas después de reforzar respuestas de estereotipia o variabilidad bajo un procedimiento de discriminación condicional fueron analizadas. Los datos analizados se tomaron de un estudio previo en el que niños y jóvenes fueron expuestos a tareas repetitivas o variadas utilizando un procedimiento de igualación de la muestra de primer orden. En la tarea de repetición se reforzaba la misma elección con respecto al ensayo anterior. En la tarea de variabilidad cuando se elegía una respuesta diferente a la del ensayo previo se consideraba como respuesta correcta. Los autores reportaron que niños y jóvenes obtuvieron casi el máximo número de aciertos en las tareas de estereotipia, mientras que en las tareas de variabilidad el número de aciertos fue menor y en pocas ocasiones se alcanzó el máximo de aciertos. Otro hallazgo fue que se encontraron efectos secuenciales de las tareas. Cuando la estereotipia era antecedida por variabilidad la ejecución no fue óptima como si

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ocurrió en el caso inverso. Un aspecto que no fue considerado en ese estudio fue el análisis de posibles secuencias de respuestas en ambas tareas. Los resultados del análisis mostraron dos patrones de secuencias: a) en la condición de estereotipia una secuencia fue la que predominó en frecuencia sobre las otras secuencias; b) en la condición de variabilidad la frecuencia de secuencias se distribuyó de manera uniforme entre las seis opciones de respuesta variable. Discutimos si el procedimiento de igualación de la muestra, además de producir estereotipia, es útil para producir respuestas de variabilidad o sólo respuestas de cambio entre las diferentes opciones.

Palabras clave: *patrones secuenciales, igualación a la muestra, estereotipia, variabilidad, homogéneas, heterogéneas, humanos.*

The validity of experimentally analyze behavioral stereotypy and variability in humans and non-human species has been well-documented in the operant literature (*e,g.*, Neuringer, 2004). Although stereotypy and variability have sometimes been examined separately, these two forms of behavior are often confronted. In the first case, persistence in repetition responses can lead to aberrant behavior of an obsessive or addictive type (among other behavioral disorders). Variability, in contrast, has been associated with behaviors that lead to originality, creativity or inventiveness. One factor shared by both behavioral phenomena is that they are susceptible for to come under the control exerted by operant contingencies (*e.g.*, Denney & Neuringer, 1998; Neuringer, 1992; 2002; Neuringer, Deiss, & Olson, 2000). To analyze the variables that strengthen these behaviors, different experimental methods have been used (*e.g.*, Machado, 1989; 1993), including procedures that produce sequences of repeated or varied responses (*i.e.*, stereotypy or variability) under requirements different or performance criteria. In studies using *lag* programs, the frequency with which different response sequences were emitted constitutes the most important data (Neuringer & Jensen, 2012). When *lag-n* reinforcement schedules are employed, the reinforcer is delivered only after the subject has issued sequences distinct from those previously emitted. In a *lag* procedure, a number of responses that form a sequence is established (*e.g.*, LLLL), but the number of sequences must be different for providing the reinforcer (*e.g.*, LLLLRRRR, in this case, *lag*-2). This procedure has proven to be effective in showing how variability can be trained and then maintained by its consequences (Page & Neuringer, 1985; Neuringer, 1991; Neuringer, 2002).

Hunzinker, Saldana, and Neuringer (1996) exposed to hypertensive (*SHR*) and *Wistar-Kyoto (WKY)* rats to three reinforcement conditions: on first condition responses were reinforced by variation under a *lag-4* program that could generate 16 possible sequences; a second condition was coupled (*yoke*); and a third involved a fixed-ratio schedule (FR4). By analyzing the frequency of sequences issued in each condition, a flattening in the distribution of the variability condition was found, which was interpreted as high variability since all possible sequences were emitted. In contrast, in the coupled and FR4 conditions, the variability sequences decreased because responding to variability was not required. These manipulations produced response peaks and, as a result, the predominance of certain sequences, ones that mostly involved switching between the two response levers (*e.g.*, LRLR, RRLR or RRLL, RLRL).

Similar results have been reported in human studies. For example, Stokes, Lai, Holtz, Rigsbee, and Cherry (2008) used tasks with different restrictions (*e.g.*, location, lag, or number of response options) and found that subjects with fewer restrictions showed less variability with repeat left or right sequences (LLLLL; RRRRR); while the highest scores were obtained by the participants who did not limit their choices to the reinforced sequences, thus showing more variable behavior. In addition, unlike the group with fewer restrictions, those subjects did not developed predominant sequences.

Although the utility of lag procedures for studying variability has been amply demonstrated, this procedure is not free of difficulties. For example, Machado (1997) has pointed out that it does not clarify whether the responses emitted by subjects are reinforced by variability or simply because showed shifts by respond from one side to the other. Hence, this procedure fails to determine exactly what is increasing, *i.e.*, the variability of responses or only by response change. Thus, the dilemma cited by Machado has yet to be resolved experimentally. If variability is not required, simple responses alternating between levers left or right (*e.g.*, LLLL, RRRR), tend to be issued more frequently; while complex sequences (*e.g.*, RLRL, LLRR, RLLR) increase only after reinforcement (Neuringer, 1993). Sequences of repetition and varied have also been brought under discriminative control. Page and Neuringer (1985) employed one discriminative stimulus to reinforce a repetition sequence (*e.g.*, LRRLL), and a different stimulus to reinforce sequences variables in a study with pigeons. Under those conditions, the pigeons learned to repeat or vary their responses according to the different training requirements. Data showed that certain sequences of repetition and varied can be maintained by reinforcement or be extinguished when the reinforcer is removed (Neuringer, 1993). These findings have been replicated by comparing the reinforcement of variability through independent reinforcement or yoke (Denney & Neuringer; 1998), and when one single sequence (*e.g.*, LLRR) and some sequences varied are reinforced concurrently (Cohen, Neuringer & Rhodes, 1990).

The importance of the lack of discriminative control has been demonstrated under similar experimental conditions, but in the absence of discriminative stimuli. Increases and decreases of repeated or varied sequences were reported by Hopson, Burt, and Neuringer (cited in Neuringer, 2002), who found the same function under both conditions, *i.e.*, when the variability contingencies were in effect, the frequency of varied sequences increased, but the repetition sequences decreased. The opposite occurred when the repetition sequence was reinforced, the repetitions increased, while the frequency of the sequences varied declined. In both cases, the unreinforced sequences were emitted occasionally, but only at low frequencies. However, discrepancies were found when comparing studies with human (Maes & van der Goot, 2006) and other species, mainly due to the density of reinforcement, procedural variations, and inter-species differences (Neuringer, 1992; Neuringer, Deiss, & Olson, 2000). Another interesting variable is when responses varied are a requirement. For example, when the variability requirement is high, the number of different sequences increases. Also, it has been shown that when variability and different levels of complex or simple response sequences are reinforced concurrently, high levels of variability facilitated learning a more complex sequence. In contrast, low levels of variability may impede or prove insufficient for learning a complex sequence. Simple sequences, in contrast, are learned regardless of the level of variability. According to Grunow and Neuringer (2002), the difficulty of a sequence correlates directly with the degree of variability required. In another study, Stokes and Harrison (2002) evaluated whether the number of response options on a pyramid task with different numbers of outputs could have an effect on the type of repeated or varied sequences. Their results showed a more structured pattern when responding to a pyramid with the highest number of output options. Two types of sequence patterns were formed: in one, repeated sequences (*e.g.*, LLLL or RRRR) decreased, while the sequences that alternated L or R responses increased (*e.g.*, RRLRL, RLRLR). The second pattern showed only a change in the sequence (*e.g.*, RRRRL and RRRLR). These findings showed that the number of response options affected the sequence patterns emitted. The authors claimed that to follow a strategy or algorithm could generate these patterns. Sequences that were emitted more frequently during reinforcement were also those issued most often during the extinction period (Neuringer, Kornell, & Olufs, 2001). However, the sequences that occurred infrequently during reinforcement increased during extinction. In the extinction phase, the number of trials that met the variability criteria increased when rats were the experimental subjects. In contrast, humans exposed to feedback and non-feedback (*i.e.*, extinction) conditions an important difference was that variability decreased during extinction (Maes, 2003).

In a study by Zepeda and Martínez (2013) the main goal was to evaluate whether the training sequence could facilitate or interfere with the learning of a task of repetition or variation on a post-training transfer test. Both kinds of training were conducted under a matching-to-sample first order procedure. Data demonstrated that a specific training sequence could affect performance in transfer test under conditional discrimination tasks. Participants generally responded to the transfer test as they had responded on the last trained task, which was called by the authors as "recency effect". Another interesting finding showed sequential effects due the order of the tasks. When training of variability preceded the training of stereotypy, the performance in stereotypy was not optimal. By contrast, when the stereotype was the first task in the sequence, performance was almost perfect. Zepeda and Martínez did not examine whether the repeated and varied responses were effectively under the control of programmed contingencies, or whether participants established a sequence pattern of stereotyped or variable responses that could be identified under the conditional procedure used. Unlike of the Lag procedure (except for lag n=1), which imposes a sequence of responses to one or two levers (*e.g.*, LLLL or LRLR) as requirement to provide the reinforcer, typical procedure of matching-to-sample involves the opportunity to respond by trials rather than continuously, since usually one response by trial is required to produce the reinforcer. Despite this procedural restriction, seems to be that the subjects did not respond independently in each trial instead participants responded by forming sequences involving repeated or varied responses throughout the trials. Analysis of these sequences was not included in the study reported by Zepeda & Martínez and we assume that such an analysis could provide further evidence on the usefulness of conditional discrimination procedures to study behavioral human stereotypy and variability.

Therefore, once sequential effects were demonstrated between phases of training, the idea was to analyze whether sequential patterns were established intra-phase under the conditions of variability and stereotypy using the data collected from the previous study. The aim of this analysis was to clarify whether participants in the variability condition responded variably, or only alternated between two response options. We assumed that if participants responded in a variable way, except for those that showed repetition, the frequencies of the sequences varied would show a homogeneous distribution among all the possible sequences. In the case of stereotypy responses, we should be able to identify whether there was predominance in the frequency of one or two repetition sequences.

Method

Since the method was published in detail in Zepeda & Martínez (2013), a brief summary of the method and procedure will be presented. Four groups of children (*n*=10 per group) and four groups of undergraduates (*n*=10 per group) were exposed to a particular sequence of training using a matching-to-sample first order task. The responses consisted of choosing a comparison stimulus that keeps one of three possible relationships between the sample stimulus and three comparison stimuli: identity, similarity, or difference. In the stereotypy condition, if the participant chose the same relationship as in the previous trial their response was followed by reinforcement (*e.g.*, choosing repeatedly the relation of difference). During variability training, in contrast, a response that differed from the relationship chosen on the previous trial was reinforced (*e.g.*, difference followed by similarity). The subjects in the first group of children and undergraduates were exposed only to the stereotypy condition. A second group was exposed only to the variability condition. A third was exposed to the stereotypy condition followed by variability, while the fourth received the reverse sequence, *i.e.*, variability followed by stereotypy. After training, all groups were exposed to a transfer test with different stimuli but without receiving reinforcement. In addition, response latency was recorded and proved to be a reliable measure for assessing the level of difficulty between the two tasks, as well as the correlation between the speed and accuracy of each response.

The results showed that performance on stereotypy was optimal by all children and undergraduates who were exposed only to this condition, as they reached a maximum number of correct responses. Although the number of correct responses in the variability condition increased during training, in no case did they reach the level of correct responses shown in the stereotypy condition. When the stereotypy condition was preceded by variability, performance was not optimal so the effects of the training sequence were evident. On the transfer test, with the exception of the group exposed to stereotypy followed by variability, participants from all other groups responded according to the previous training showing effects of recency.

From this point we introduce the analysis of the sequences that occurred during stereotypy or variability training and the transfer test in the study of Zepeda and Martínez (2013), which constituted the focal purpose of this paper.

Analyses of sequences

To carry out the analyses proposed, we took data from the repetition and varied responses from each of the four groups of children and undergraduates, regardless of whether they responded correctly or incorrectly. It is important to remember that a varied sequence in the stereotypy condition and a repeated sequence in the variability condition counted as incorrect responses. However, because our interest was to identify possible sequential patterns in the two types of training, we grouped the repeated or varied sequences regardless of whether the responses were correct or incorrect.

Frequency percentages of stereotypy and variability sequences

The first step was to analyze the differences between the percentages of repeated and varied responses produced during the conditional discrimination procedure, regardless of the training sequence followed by subjects in all groups of children and undergraduates. In the stereotypy condition, if the election in trial *n* was equal to the previous choice (*n*-1) it was followed by reinforcement. In contrast, in the variability condition, if the election in trial *n* differed from the previous one, *that* response was reinforced. After calculating the percentages, if after the respective training conditions both responses showed higher frequencies, and then we could assume that the procedure was effective in exerting control over repeated and varied behaviors. Also, we attempted to represent the repeated and varied sequences according to the phases of training to emphasize performance differences for each group.

Frequency distribution of stereotypy and variability sequences

After confirming the increased frequency of repeated and varied responses, the next task was to analyze the distribution of these two responses in the two experimental conditions. To that end, we grouped the possible sequences as ‘homogeneous’ and ‘heterogeneous’. The former included the pairs of repeated responses, while the latter were made up of pairs of non-repeated responses. This procedure generated a universe of nine possible sequences, three of which were repetitive: identity-identity (II), similarity-similarity (SS), and difference-difference (DD), and so were categorized as homogeneous. The other six sequences were varied: identity-similarity (IS), identity-difference (ID), similarity-identity (SI), similarity-difference (SD), difference-similarity (DS), and difference-identity (ID). These six varied sequences were labeled heterogeneous.

Analysis of the stereotypy and variability sequences on the transfer test

It has been shown that withdrawing reinforcement increases variability levels, as occurs in typical extinction procedures (Neuringer, 1993). Because reinforcement was removed from the trials of the transfer test, responses were recorded regardless of whether the responses were correct or incorrect;

therefore, these trials were used to assess participants' choices after training in stereotypy and variability. In this session, repeated and varied sequences also occurred and were analyzed. Because of the visual clarity of the data examined, we did not consider it necessary to apply a statistical analysis to establish the differences between the training conditions and among the groups of children and undergraduates, though a more refined quantitative analysis was not ruled out. We assume that the plots describe the data adequately and can serve as the basis for interpreting results.

Results

Figure 1 shows that the percentage of sequences under stereotypy/stereotypy training the children's performance (upper panel) was mostly stereotyped with few variability sequences, while that of undergraduates (bottom panel) was almost 100% in both training phases. When only variability training was providing, the percentage of varied sequences by undergraduates was around 80%, while repeated sequences reached 20%. When stereotypy training was followed by variability, the undergraduates performed 100% repeated sequences and children 90% and 10% varied. When variability training was followed by stereotypy, children and undergraduates reached maximums of 80% and 20% of varied and repeated sequences, respectively. These data demonstrate that both behaviors (*i.e.*, repeat and varied) were under the control of programmed contingencies.

Figure 2 shows the percentage of each one of the nine possible sequences emitted under the different training conditions for children (upper panel) and undergraduates (lower panel). On the horizontal axis shown the first three repeat sequences (*i.e.,* Identity-Identity, Similarity-Similarity and Difference-Difference) followed by six sequences of variation (*i.e.,* Identity-Similarity, Identity-Difference, Similarity-Identity, Similarity-difference, Difference- Identity and Difference-Similarity). The graphs in the left column show that except for the stereotypy-variability group of children, which produced more Difference-Difference sequences, when the stereotypy condition was trained first (light gray bars), there was a marked predominance of the Identity-Identity sequence. The emissions of the other two repeat sequences and all six varied sequences were practically zero. This pattern was maintained when the second phase of training (dark gray bars) also consisted in stereotypy. The right column shows the graphs when the first phase of training was variability (light gray bars), where the frequency percentages were distributed among all sequences, including the repeated sequences. The same pattern was maintained when variability was presented as the second phase (dark gray bars).

When stereotypy was the second phase of training, the children scored the highest percentage (50%) for the Different-Different sequence, with 25% for the Identity-Identity sequence, and a minimal result for the Similarity-Similarity and varied sequences. The undergraduates had the highest percentage for the Identity-Identity sequence (62%), a lower percentage for Difference-Difference (20%), and the lowest score for the Similarity-Similarity and varied sequences. In addition to confirming the control exerted by contingencies over stereotypy and variability behaviors, we identified a pattern of persistence that involved choosing a repeated sequence in the stereotypy condition and a pattern of responding with all possible sequences in the variability condition.

Figure 1. Total percentages of sequences repetition and varied per group under each of the four training sequences and transfer test. Dark bars correspond to repetition sequences (stereotypy) and the gray bars represent the sequences varied (variability). The upper panel shows the four graphs for the groups of children; the lower panel the four graphs of the undergraduates.

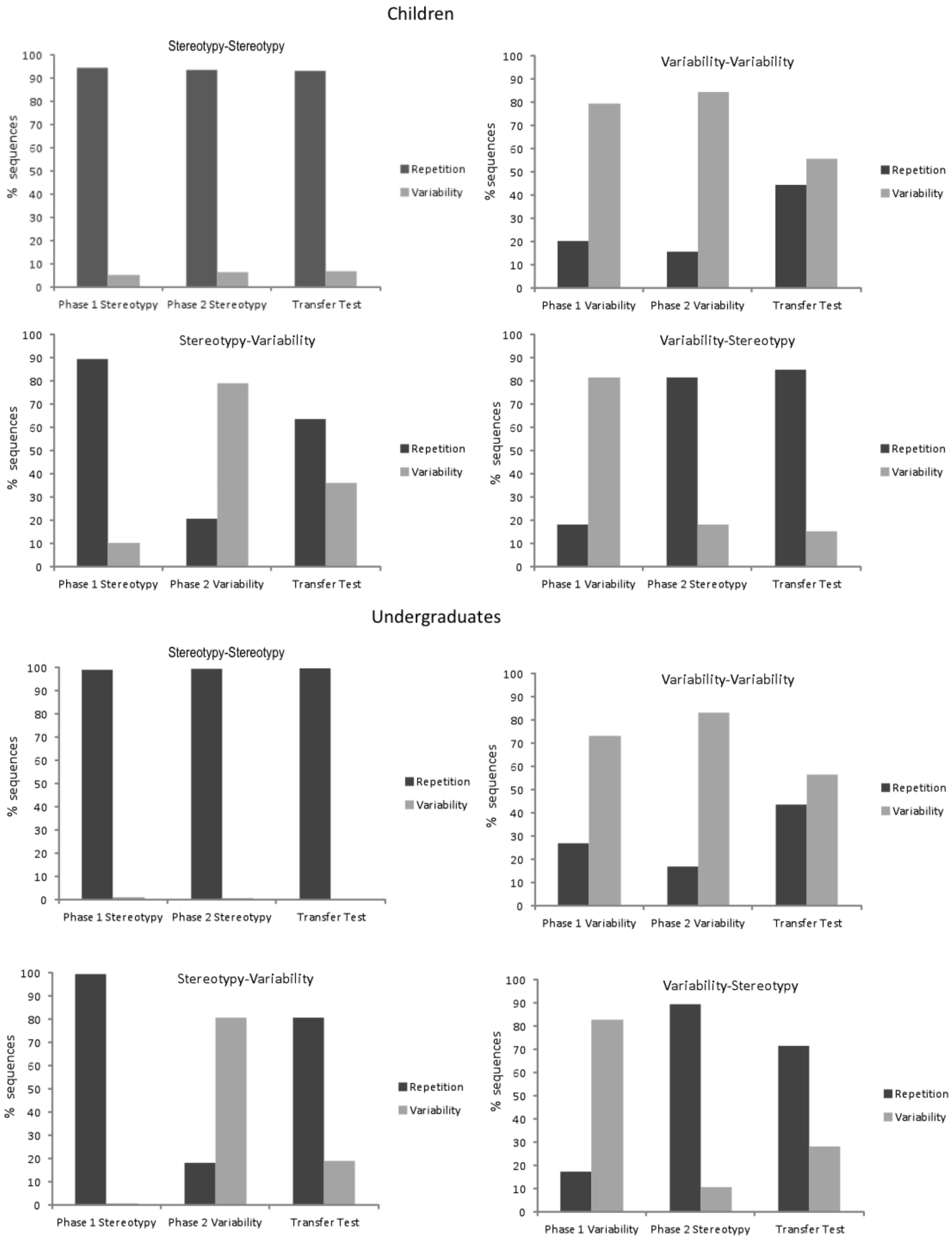

Figure 2. Percentages of stereotypy and variability sequences under each of the four training sequences and transfer test. The upper panel shows the four graphs for the groups of children; the lower panel the four graphs of the undergraduates. The first three sequences on the horizontal axis correspond to the stereotypy sequences; the following six to variability sequences. For each graph, the light gray bars represent the sequences emitted in the first training phase, the gray bars those of the second phase, and the dark bars those issued during the transfer test.

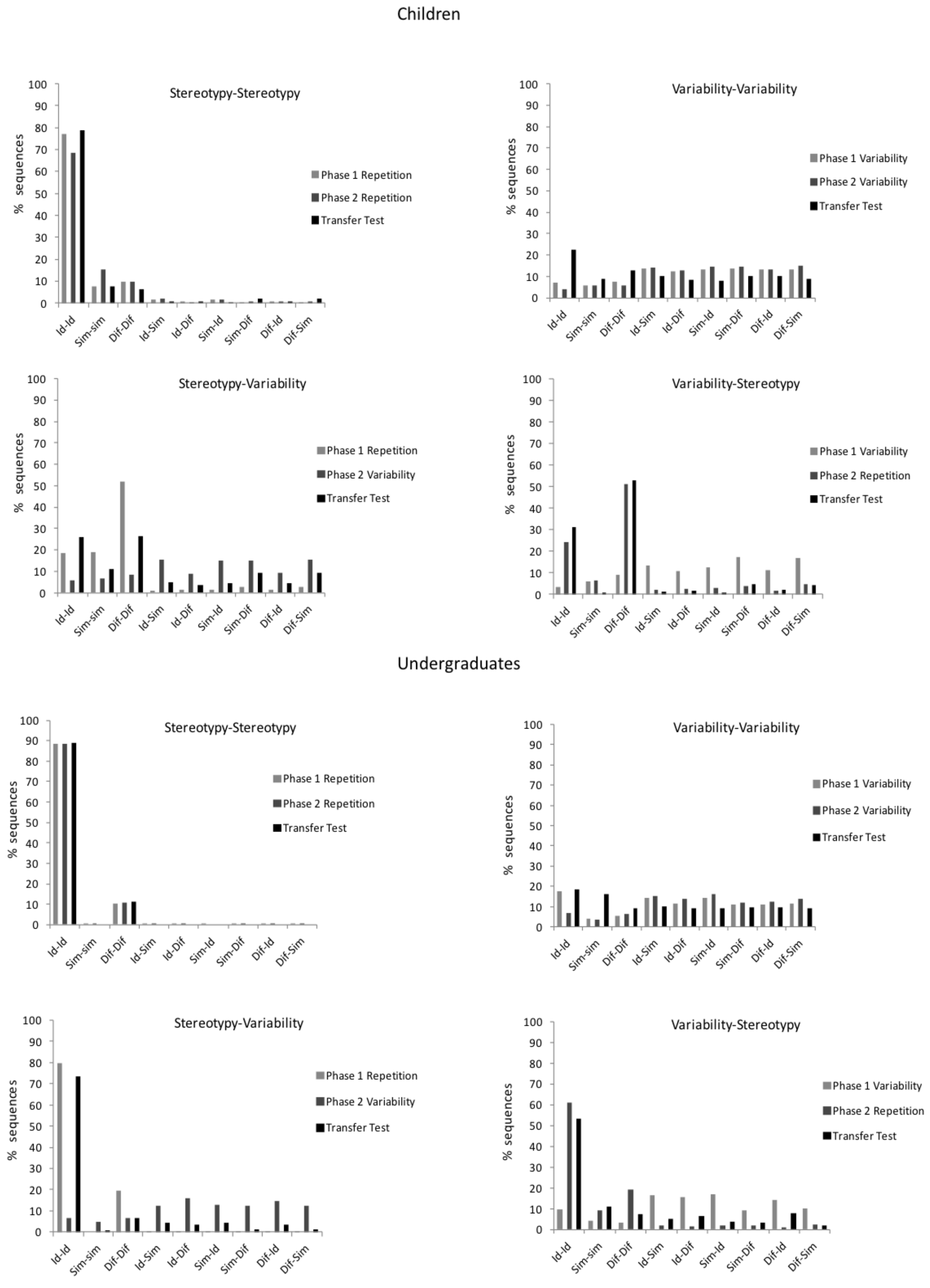

Figure 3. Percentages of sequences homogeneous (HH) and heterogeneous (HT) for each group under the training conditions and transfer test. The upper panel shows the four graphs for the groups of children and the lower panel the four graphs of the undergraduates. Yellow bars represent the homogeneous sequences (stereotypy) and the bars with other colors the heterogeneous sequences (variability).

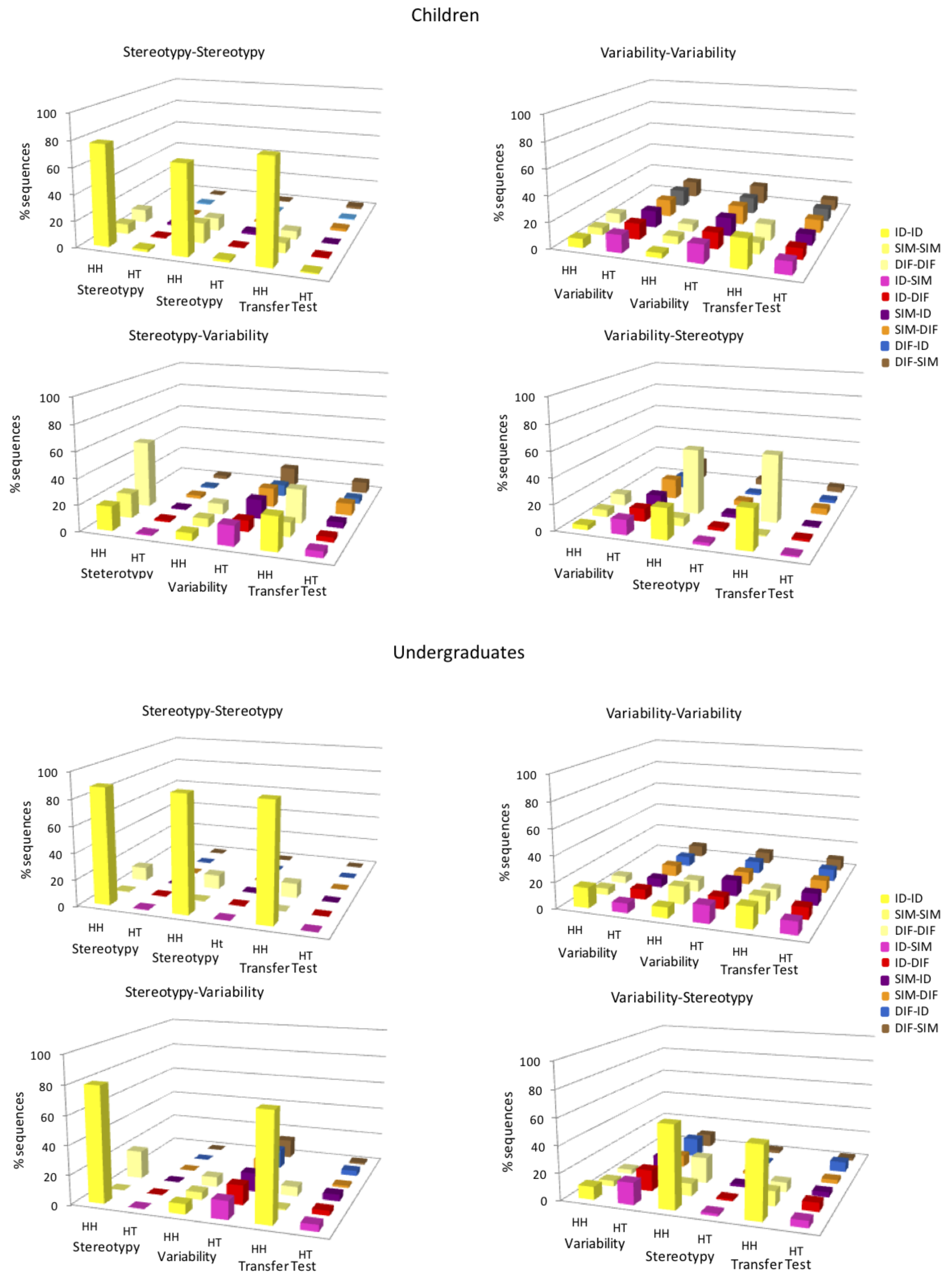

Figure 3 shows another way of representing the percentage of sequences for each training phase after grouping the three repeated sequences (Identity-Identity, Similarity-Similarity and Difference-Difference) in a more general category, which we named homogeneous category, and the six varied sequences (Identity-Similarity, Identity-Difference, Similarity-Identity, Similarity-difference, Difference-Identity and Difference-similarity) in the category labeled heterogeneous. This way of representing the sequences emitted made it possible to identify the pattern of repeated and varied sequences in each training phase more clearly. The yellow bars represent the three repetition sequences, while the colored bars show the six sequences varied. Data showed that under the stereotypy condition there was a concentration of repetition sequences with a minimum number of sequences varied. In contrast, under the variability condition, the frequency of the sequences varied was distributed uniformly, including the repetition sequences. If subjects responded with only a couple of alternated sequences (*e.g.,* Identity-Difference and Similarity-Difference), which would have been sufficient to receive the same amount of reinforcement, the percentage of those sequences would have been higher and the other sequences would not have occurred. In contrast, the uniform distribution of the frequencies of all nine possible sequences in the variability condition showed that this pattern did not occur under this procedure.

The data from the transfer test depicted in Figure 1 (third pair of bars), Figure 2 (black bars) and Figure 3 (last two series of bars), show the sequences chosen when participants in all groups were exposed to 36 trials with different training stimuli without reinforcement, so that in this session there was no criterion of correct responses. Figure 1 shows that with only a few exceptions, participants responded according to the last training phase received. Subjects form the groups that received only stereotypy training chose repetition sequences at the same percentage as in the training phases. Participants from groups that received only variability training showed similar percentages by choose more sequences varied (60%) than repetition. Participants from the stereotypy/variability training groups chose a higher percentage of repetition sequences than varied ones, despite that variability was the last training phase. Finally, participants with variability/stereotypy training selected a higher percentage of repetition sequences (80% and 70% for undergraduates and children, respectively) and fewer varied sequences. Figure 2 (dark bars) and Figure 3 (last two series of bars) represent the distribution of the repetition and varied sequences during the transfer test confirming that there was an influence on the emission of sequences in last training phase.

Discussion

The main results of these analyses can be summarized as follows: a) after stereotypy training, participants persistently responded with a single sequence and few responses of variability; b) variability training produced a flat distribution with low frequencies for all heterogeneous and homogeneous sequences; and, c) the transfer test confirmed that with the exception of the stereotypy-variability undergraduate group that responded with homogeneous sequences, all other subjects responded with the same sequences as in the last training phase. Finally, we identified two general response patterns: a) in the case of stereotypy training, a pattern of persistence in responding to a sequence; and, b) for variability training, a uniform distribution pattern of responses with low frequencies of homogeneous and heterogeneous sequences.

Unlike our procedure, in Neuringer's study of the interaction or relationship between stereotypy and variability, the two forms of behavior were usually trained concurrently (*e.g.*, Neuringer, 1992). For example, human studies in which the dimension repetition of the task was reinforced while other dimensions were varied, demonstrated that the two tasks can be reinforced concurrently and that subjects were capable of responding differentially under the contingencies that operated for each condition. Ross and Neuringer (2002) noted that, depending on the contingencies and the goal to be achieved, variability could be functional, while in others repetition or combinations of the two are functional too. Although both tasks were required in succession, rather than simultaneously or concurrently and therefore were reinforced separately, results showed that both types of response can be trained separately and produce response patterns that meet the requirement of reinforcement. Neuringer, Deiss, & Olson (2000) examined the possible sources of behavioral variation in the context of Skinner's theory of selection, arguing that variability can be produced through direct reinforcement; that is, explicitly reinforce variability may exert precise control on levels of variability. Our data confirmed this assertion, for when the variable sequences were explicitly reinforced their frequency increased markedly. Barba (2010, 2012) and Machado and Tonneau (2012) have emphasized that some sequences are more prevalent than others when variability is reinforced, but this was not confirmed in our study because the frequency of sequences varied was uniformly distributed among all possible sequences and no predominance of any specific sequence varied. One could argue that, unlike most studies of sequences using lag programs, our data showed that probably the choice of all sequences is maintained because they are simple sequences compared to those that may occur under a lag program, especially if the lag value is high. In this case, variability is usually maintained, but with a tendency to reduce emissions of sequences because the universe of possible sequences is relatively high (Souza, Abreu-Rodrigues, & Bauman, 2010; Neuringer, Kornell, & Olufs, 2001).

Although it is not the purpose of this report compare different procedures designed to study variability, it is important to note that there are various ways to calculate the variability produced. For example, Neuringer (2002) set the U value, a statistical index that measures levels of uncertainty, which has often been used in studies of operant variability. The U value makes it possible to calculate the relative frequencies of individual responses (A and B), pairs of answers (AB, AA, BA, BB), and triads of responses (ABC, ABB, CBA, etc.). The number of responses available in the procedure is relevant for defining the universe of possible sequences. Thus, the U value is a function of the relative frequency of each sequence and the universe of all possible sequences (Barba, 2012), such that when a sequence occurs all the time, the U value is equal to 0, while when the frequency relative of all sequences is uniform, the U value approaches 1. Compare the uncertainty index, U, with other measures of variability may produce mixed results (Maes, 2003). Other methods of analyzing variability that record the percentage of reinforced sequences or the percentage of correct responses in a number of trials also have used the U-value as a measure of variability (for a review see Barba, 2012). We did not use the U value to measure variability for several reasons. First, an uncertainty index does not appear to be the results of reinforce sequences varied; rather, the uncertainty term mean to doubt or indecision. Subjects who have been exposed to various procedures that generate variability do not seem to respond in a doubtful way, or to emit responses that result from indecision. On the contrary, evidence shows that they did respond in a well-defined direction (*i.e.*, according to established contingencies). Uncertainty is an index that obscures the control exercised by reinforcement as revealed by the increase in behavioral variability. That index does not seem to represent clearly the variables that operate on increasing or maintaining variable behavior. Second, determining variability levels using the U index requires considering all possible sequences in addition to those that actually occur. Thus, variability is measured according to the relative probabilities of all response sequences and not with respect to the response sequences that are concretely emitted during the experimental situation. The U value has probably been the most useful of the lag procedures, where the variability requirements applied to subjects demand the emission of a large number of different sequences to produce reinforcement (*e.g.*, lag 25 or 50). It is unclear to us why it is necessary to require the emission of a large number of different sequences to show that variability behavior has been established after receive reinforcement. Third, to our knowledge, the matching-to-sample procedure has not been widely employed to study stereotypy and variability in humans, though this procedure includes the feature of a conditional discriminative behavior, produces accurate responses, and specifies performance criteria that are easily measured. In fact, the dependent variable most commonly used is the percentage or number of responses after a series of trials. For example, in our study the procedure included responses based on pressing one of three buttons, and response criteria were specified based on the relationship between the comparison stimuli and the sample in each trial. The location of the comparison stimuli varied from trial-to-trial (*e.g.*, Identity, Difference and Similarity), so repeat the same response key did not produce a correct response in the case of stereotypy, and changing from one key to another without considering the relationship between each comparison stimulus and sample did not guarantee a correct varied response. As a result, responses of repetition and variable occurred according to programmed contingencies. For example, the children exposed to the stereotypy/variability and variability/stereotypy training chose a higher percentage of the Difference-Difference sequence compared to undergraduates, who chose the Identity-Identity sequence almost 80% of the times under stereotypy training. When this was not the case, it was possible to identify the wrong response in each of the sequences emitted. These advantages of procedural and measurement corroborated that it is pertinent to study stereotypy and variability behaviors in human using the conditional discrimination paradigm. Under these conditions we can assume that the varied sequences produced reflected reliable variability and not simply responses that changed from one relationship to another by alternating between two sequences. The uniform distribution of the frequency of all possible variable sequences does not justify speculation that the participants were just changing from one relationship to another, for in such a case the data would be quite different, as they would show few variable sequences with high frequencies compared with the rest of the sequences varied. In contrast, the repetition sequences showed predominance of one specific sequence over all others. These two ways of responding closely approximates the shapes of two well-defined patterns: one of stereotypy and the other variability.

Neuringer (2012) has discussed the effectiveness of the feedback provided at the end of each trial which functions as a conditioned reinforcer. However, feedback was combined with instructions in that study, therefore Neuringer could not determine whether feedback fulfilled that function. In our study, the instructions did not referred to the tasks and do not seem to have played a role that could have interfered with, or facilitated, the control exerted by the programmed contingencies on the stereotypy and variability sequences. In an unpublished study, we examined the effects of varying the density of feedback under the same experimental conditions as in the original work by Zepeda and Martínez (2013). The feedback was delivered in each trial, every third trial, or at the end of each session. Results showed that delayed feedback at the end of the session negatively affected the control exerted on stereotypy and variability responses. The transfer test, in which feedback was removed, showed a recency effect since, in general, the same sequences that were reinforced in the last phase of training were maintained. Neuringer, Kornell, and Olufs (2001) have reported that sequences with lower probabilities of occurrence increased during extinction, but the hierarchy of preferred sequences produced by reinforcement did not change. However, data published in a study by Schwartz (1982) showed that after reinforcement of specific response sequences, pigeons responded to the most frequent sequence, and that this performance was not modified during extinction.

In conclusion, we attempted to approach the study of stereotypy and variability in humans using a matching-to-sample method which produced results that allow us to continue exploring variables related to the establishment of responses of stereotypy and variability. Our analysis of the sequences allowed identifying sequential patterns consistent with scheduled contingencies, as well as providing evidence that the sequences varied produced were not responses of alternation that simply shifted from one option to another.

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