Tree or Forest: The Effect of Mood on Rule Induction

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Abstract

During the process of language acquisition, children and adults have to induce the rules of the new language (native or second). The process of rule induction has been shown to be affected by differences in individuals' cognitive capacities, such as memory (e.g, Hudson Kam & Newport, 2005). On the other hand, individual differences in mood can also affect attention and cognition; in relevant studies, a general effect that has been observed is that people in a negative mood tend to follow a more detailed, item-based and systematic way of processing, whereas people in a positive mood might follow a more creative, category-based way of processing, relying more on heuristics (e.g., Clore & Huntsinger, 2007). Since cognition has an effect on rule induction, and mood has an effect on cognition, could mood ultimately affect rule induction? This study focuses on the differences that adult participants in positive and negative mood conditions might exhibit with respect to rule induction. The main hypothesis is that individuals in a negative mood will have a lower capacity for rule induction, while individuals in a positive mood will have a higher such capacity. We further tested whether the effects of mood on cognition would be observed in a visual perceptual task, as a means of testing whether mood affects cognition overall, or particular cognitive capacities only. The results indicated that participants in a negative mood had a lower tendency to identify the general underlying rules of the artificial grammar and to accept novel grammatical strings as correct, compared to participants in a positive mood; no similar effects were found for the visual perceptual task. Implications for differences in the effects of mood on cognition, and applications in educational settings, are discussed.

Key-words: mood, rule induction, item-bound, category-based, visual perceptual focus

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1. Introduction

"In the world according to the positivist, the inspiring thing about scrambled eggs is that any way you turn them they're sunny side up. In the world according to the existentialist, the hopeless thing about scrambled eggs is that any way you turn them they're scrambled." (Tom Robbins, *Still Life with Woodpecker*). What is it then that makes scrambled eggs inspiring in the eyes of the positivist, and hopeless in the eyes of the existentialist? Apart from one's life philosophy, one's personality trait might also make a person more prone to certain mood states or emotions; in other words, affective states. The message of this quote lies in something that all humans experience, namely, affective states, which influence the way we think about the world around us, as they have an effect on our cognition and attention.

The term "affective states" is a rather broad umbrella term including emotions and moods. There are many definitions for affective states, most of which agree in the following aspects; while emotions are (neuro)physiological and behavioral responses to a specific stimulus, bursting and rather short-lived, which directly change our actions (e.g, fear, anger), moods refer to affective states of a milder nature, which do not always have a clear cause, and are more enduring (Cacioppo, Berntson, Larsen, Poehlmann, & Ito, 2000). This is also why the general terms "positive" and "negative", or "happy" and "sad" are usually sufficient to describe the status of one's current mood, and are widely used as such in the relevant literature (e.g., Brand, Reimer, & Opwis, 2007; Palfai & Salovey, 1993; Clore & Huntsinger, 2007; Fredrickson & Branigan, 2005).

How exactly does one's affective state influence his/her perception of the world? The present study focuses on mood, which has been shown to have an effect on various cognitive tasks. Previous studies point out the effect of mood on learning and transfer effects (Brand et al., 2007), inductive and deductive reasoning (Palfai & Salovey, 1993), decision making (Isen, 2001), recall and memory (Bower, 1981). Mood is further associated with language-specific cognitive tasks, such as syntactic processing (Vissers, Virgillito, Fitzgerald, Speckens, Tendolkar, van Oostrom, & Chwilla, 2010), and discourse-related implicit causality bias (van Berkum, de Goede, van Alphen, Mulder, & Kerstholt, 2013). In general, the effect that has been found in such studies is that a positive mood broadens the spotlight of attention, leading to a more "category-level and global processing", while negative mood narrows the attentional focus and leads to a more "item-level and local processing" (Clore &

Huntsinger, 2007, p. 394).

Since mood has an effect on a variety of cognitive processes, a central question in this paper is whether the mood can also affect language acquisition. Language acquisition is a unique and robust phenomenon; from a finite amount of input, humans can produce an infinite amount of new linguistic structures. In order to achieve this, it is crucial to classify the words of their input into their corresponding grammatical categories, to identify regularities in the input, and to induce the underlying rules. The terms “rule induction”, “categorization”, and “regularization” refer to this process, which in experimental settings is usually tested with artificial grammars. The results of several studies support the idea that rule induction is affected by the distributional properties of the input, (Reeder, Newport, & Aslin, 2009; Radulescu, Wijnen, & Avrutin, submitted), and impeded by components of the working memory (Hudson Kam & Newport, 2005; Hudson Kam & Chang, 2009; Radulescu, Giannopoulou, Wijnen, & Avrutin, in prep.), and positively affected by pattern recognition capacity (Radulescu, Giannopoulou, Wijnen, & Avrutin, in prep.). Furthermore, it can definitely be related to reasoning and problem solving, especially when we refer to second language acquisition (for instance, Block (1986) for second language readers).

As discussed above, mood has an effect on various cognitive capacities, such as learning, memory, reasoning, problem solving, and syntactic processing. These capacities can also be related to rule induction in language and have an effect on it (as shown in previous studies). Hence, it would stand to reason to assume that mood could also have an effect on rule induction. Nevertheless, this effect has hardly been explored. The present study aims to cover this gap by investigating the effect of mood on adults’ ability for rule induction in an artificial grammar task. The main research question of this study is: what is the effect of positive and negative mood on rule induction? The ultimate goal of the study is to contribute to our further understanding of the complex process of (second) language acquisition, and the mechanisms that facilitate it.

2. Theoretical Framework

2. a. Rule Induction and Cognitive Capacities

In relevant literature, rule induction, regularization, and category learning (all referring to the same process of categorizing words according to a rule, or extracting the rules and regularities which underlie the input) were experimentally tested with artificial grammars (Reber, 1967). These grammars are based on rules which are analogical to structures that we find in natural language; these rules can either be adjacent (e.g., AAB) or non-adjacent (e.g, AXC, where A determines C and X is a variable that takes different values). Artificial grammars are learned in an implicit way, in the sense that the rules are not explicitly taught. Implicit learning is a general cognitive mechanism, automatic and unconscious, which facilitates learning of tasks such as artificial grammars (Reber, 1967); according to Reber (e.g., 1967, 1992, 1993) it is clearly distinct from explicit learning.

In experimental situations, artificial grammar learning demonstrates participants' capacity for rule induction. Rule induction in language can have two outcomes: item-bound generalizations, which are based on specific items and their perceptual features (e.g, *pre-* is followed by *–tty* in the word *pretty*); and category-based generalizations, which are abstract rules applying to different variables in each instance (e.g, the structure Noun-Verb-Adverb for sentences, which can take any value for *noun*, any value for *verb*, etc.) (Gomez &Gerken, 2000). For the former type of generalization, it is possible to memorize the specific relations between items. But what happens with the latter type of generalization? We believe that this more abstract form of rule induction must be a product of reasoning and more complicated processes than plain memorization.

The theories about the cognitive processes that lead to these two types of generalizations are split: it is either believed that there is one learning mechanism, resulting in either item-bound or category-based generalizations (Aslin & Newport, 2012; Reeder et al., 2009); or that there are two independent learning mechanisms, one that leads to item-bound generalizations, and a separate one leading to category-based generalizations (Marcus, Vijayan, Rao, & Vishton, 1999). In the former case, the single learning mechanism is statistical learning, which refers to computation of the statistical regularities and probabilistic distribution of items (Saffran et al., 1996). In the latter case, there are two mechanisms leading to two different types of generalizations: statistical learning is the mechanism which leads to learning of statistical information, and abstract rule-learning, which refers to algebra-like manipulation of variables, and facilitates the learning of "algebraic rules" (which corresponds to "category-based" generalizations, according to the Gomez & Gerken terminology).

Whichever of the two approaches mentioned above holds (two separate mechanisms or one mechanism which has a qualitative change), there must be a cause for the change, either the change from one learning mechanism to the other, or the qualitative change within the same mechanism; otherwise, the distinctions between the two types of rule generalization and the learning mechanism(s) that facilitate them would be pointless. In an aim to answer these questions, Reeder et al. (2013) conducted experiments with adult participants in order to investigate how the distributional properties of the input affect the generalization process. They used an artificial grammar with the structure (Q)AXB(R), where each letter represents a set of two or three words. The elements in the parentheses are optional, and were used in occasion in order to test whether adding them would affect the generalization process of the variable X.

The aim of the experiments was to investigate if participants would succeed in generalizing the X as a variable, able to take different values each time (category-based generalizations, according to the Gomez & Gerken (2000) terminology), or if they would fail to do so, and would only remember the specific item occupying the X position (item-bound generalizations, according to the Gomez & Gerken (2000) terminology). The results indicated that the factors which have an effect on generalization are: high overlap of contexts (experiment 1), which refers to many different contexts in which the variable X might appear; sparseness (reduced density) of input (experiment 2), which refers to less input; incomplete overlap of contexts (experiment 3), which refers to contexts in which the variable in question might appear, but in such a way that it does not overlap; and extended exposure (experiment 4), which refers to more input. More specifically, sparseness of input and high overlap of contexts facilitated category-based generalizations, while on the contrary, incomplete overlap of contexts, and extended exposure to the input impeded the induction of category-based generalizations. These results indicate that the incomplete overlap of contexts constrained category-based generalizations. We could assume from this result that participants did not have enough “safe” information to reach a more general rule which could apply to multiple instances. In addition, the results showed that extended exposure also did not facilitate the induction of category-based rules. Although Reeder et al. did not explicitly test the effects of memorization on rule induction, we could interpret these results by assuming that the participants probably had a strong memory trace of the specific item in the X position, thus forming item-bound generalizations.

It appears, then, that the factors which trigger this leap from item-bound to category-based generalizations are not restricted to the probabilistic distribution of the input, but also have to do with the cognitive abilities and limitations of the human brain, such as memory capacity. Indeed, components of working memory are often seen as a constraint in the process of regularization and category-based rule induction in language. Hudson Kam and Newport (2005) performed 2 experiments to compare how adults and children would learn an artificial grammar with inconsistent and unpredictable variations in one grammatical feature (determiner). The first experiment was only with adult participants, while the second one tested children and adults. In both experiments, participants were taught the same artificial language and had to complete several tasks afterwards (forced choice tasks, sentence completion tasks, vocabulary tests, grammaticality judgment tests). Results showed that child participants had a higher tendency to regularize and apply patterns on the complex input. The authors interpret these results with by turning at differences in working memory: children are unable to learn all the complex and inconsistent material, due to their underdeveloped working memory capacity; thus, they regularize. Adults, on the other hand, manage to maintain the varied and complex material in their more developed memory capacity; hence, they do not have such a high need to regularize.

Following the same assumptions about memory's constraining role in rule generalization, Hudson Kam and Chang (2009) hypothesized that one of working memory's components, word retrieval, functions as an obstacle in regularization; therefore, the lower the memory capacity, the higher the tendency for category-based generalizations. To test this, they presented adults with two different versions of the same (NEG)-V-S(-O) artificial language (Negation-Verb-Subject-Object); one with a more complex structure, where the items in the parentheses (NEG and O) are included, and a less complex version, excluding the items in parentheses. Participants had to complete a sentence production task, which was manipulated in two versions (easy and standard condition). They also had to complete two other non-production tasks: a determiner judgment task and a sentence structure judgment task. There was a further test manipulation, where participants were in two conditions, one with more demanding word retrieval, and another one with less cognitively demanding word retrieval (where they used flashcards to show participants the nouns, verbs and determiners of the language). The results showed that when word-retrieval is less demanding (as in the flashcard condition), there is a higher tendency for regularization.

Lastly, it is important to note the role of attention in the process of learning an artificial grammar and extracting the rules. Tanaka, Kiyokawa, Yamada, Dienes, and Shigemasu (2008) conducted 2 experiments to test whether selective attention influences artificial grammar learning. The tests were based on strings named GLOCAL: as the name reveals, they had differences in their global and local aspects (i.e., each one of the letters of the string consisted of smaller, different letters, as the figure below reveals).

Figure 1: exemplary string by Tanaka et al. (2008)

The experiments included two types of GLOCAL strings, which were both based on two different artificial grammars; the first type of GLOCAL strings was based on one of the grammars at the global level and the second grammar at the local level, and the second type of GLOCAL strings was made by the opposite grammars on a global and local level. The GLOCAL strings were presented visually during the training phase (each GLOCAL string was presented 6 times in total). At the test phases, two strings would appear on the screen, and participants had to judge which one of the two is grammatical. The results showed that participants would only classify a string as grammatical if it belonged in the level of the GLOCAL string they attended to (global or local), thus demonstrating the role of selective attention in artificial grammar learning; the GLOCAL strings included two grammars which occurred simultaneously; however, the participants only learned the grammar of the level they attended to.

The role of attention was also discussed in López-Barroso, Cucurell, Rodríguez-Fornells, de Diego-Balaguer (2016). They performed 2 experiments; the first experiment investigated the effect of attention on learning an artificial grammar with non-adjacent rules (AXC, where A determines C, while X is a variable changing regardless of its context). During their training phase, participants were aurally presented with 36 grammatical AXC phrases and 18 XXX filler phrases. Meanwhile, they performed a word-monitoring task; at times, a word (always a C word) would appear on the screen, and participants would have to press the right button if the target word was present in the phrase they heard, or the left button if the word was not present in the phrase. The word-monitoring task was a means of attention manipulation, as it should direct the participants' attention to the A elements of the AXC structures, which would help them predict the C element quicker and respond faster. After that, they immediately went to an (implicit) test phase, which resembled the training phase, only the XXX filler structures were replaced with XXC non-rule structures. Lastly, there was an (explicit) test phase, where participants had to click the left-mouse button for phrases that belonged to the pre-exposed language, and the right button for phrases that did not. The reaction times of the participants during the implicit test phase indicated that there was a significant effect of attention on rule learning; the word-monitoring task facilitated them in responding faster in grammatical AXC structures that they heard previously. The second experiment was performed one day after the first one. It was performed in order to test the consolidation effects on the more explicit knowledge of the rules. The exact same procedure was followed as in the first experiment, with different AXC, XXX, and XXC phrases in order to avoid repetition. No significant effects were found.

In conclusion, these studies provided useful insights with respect to rule induction; the distributional properties of the input and working memory components affect rule induction in language learning, while attention is also a determining factor in the process of learning itself. How do all these factors, combined in a unified framework, affect rule induction?

2. b. An Entropy Model for Linguistic Generalizations

In an attempt to answer the question posed above, Radulescu (2014) introduced an entropy model for rule induction in language acquisition based on two information theoretic concepts: entropy and channel capacity. Entropy, as presented by Shannon (1948), is an information theoretic concept which describes the unpredictability in a set of members: the higher the entropy, the higher the unpredictability of items in the set to occur, and the complexity of the set; the lower the entropy, the higher the predictability and the probability of the same items occurring multiple times. High entropy occurs when there is equal probability of all the members in a set to appear, while low entropy occurs when a few members of the set are more probable to appear, compared to others. In the Radulescu (2014) framework, entropy is used to quantify the complexity of the incoming information (input complexity). A high amount of entropy refers to highly complex and unpredictable input, whereas low entropy refers to non-complex, repetitive and predictable input. The second information theoretic concept used in Radulescu (2014) model is “channel capacity”, which describes the amount of information that can be processed (in bits). Channel capacity is a model for individuals’ cognitive abilities and limitations, and it is hypothesized to consist of pattern recognition capacity, and of components of the working memory capacity. However, it is still not clear what cognitive capacities modulate channel capacity.

Based on the above, rule induction depends on how complex the input is, and how small or big the channel capacity will be (how much information can be processed). The main hypothesis of the model is that a small channel capacity (particularly memory capacity) will lead to more category-based generalizations, because the ability of memorizing specific items and their perceptual features is limited; thus, it is necessary to generalize and induce more abstract rules (category-based generalizations, as they were described in section 2.a.), because the information that is presented has an *input complexity* which exceeds the *channel capacity*. On the other hand, when the channel capacity (particularly the memory capacity) increases, there is a higher ability for memorising specific items and their perceptual features, thus there will be a higher tendency for category-based generalizations, and a higher tendency for item-bound generalizations. Contrary to memory capacity, pattern recognition is hypothesized to facilitate rule induction; the higher the pattern recognition capacity, the higher the tendency to induce category-based generalizations. Another hypothesis of the model is that there is one learning mechanism which leads to rule induction, and it can have two different outcomes: item-bound generalizations, and category based generalizations; the same mechanism can account for both types of generalizations, and there is a qualitative change in the mechanism, as a result of the differences in entropy.

To test these predictions, Radulescu, Wijnen and Avrutin (submitted) carried out two experiments in the AGL paradigm. The experimental task consisted of 3 training phases, each of which was followed by a test phase. The stimuli presented during the training phase differed per condition (Low Entropy–Medium Entropy–High Entropy). Based on the description of entropy given above, input with high entropy refers to more complex and less predictable stimuli, compared to input with medium and low entropy, where the stimuli are more repetitive. It was assumed that the channel capacity (the second component that contributes to rule induction) was kept constant, as the sample of participants was highly homogenous (age 19-26, mostly female population, similar educational background). The results indicated that participants in the high entropy condition had a higher tendency for category-based generalizations, compared to the participants in the other two conditions; the high amount of complexity could not be stored in an item-based manner, so the need to store the information made the participants “tune in” a more abstract way of encoding.

To further test the effect of channel capacity on rule induction, namely the individual differences on cognitive capacities and their effect on rule induction capacity, unpublished experiments were carried out within the same framework (internship experiment-Radulescu, Giannopoulou, Wijnen, & Avrutin, in prep.). Participants were tested in rule induction and three other cognitive tasks (explicit memorization, incidental memorization, visual pattern recognition). The rule induction task was the same artificial grammar task that was used in the previous Radulescu et al. (submitted) experiments. This time, the entropy condition was kept constant at Medium (according to the entropy conditions mentioned above), as the scope of attention was turned on the channel capacity, and not on the input complexity. According to the hypotheses of the Radulescu et al. framework, visual pattern recognition capacity was expected to have an effect on rule induction capacity, while components of the working memory, specifically incidental memorization, were predicted to impede the rule induction process, particularly the induction of category-based generalizations. The results confirmed the hypotheses: visual pattern recognition capacity had a significant positive effect on rule induction capacity, while incidental memorization had a significant negative effect on rule induction capacity. No significant effects were found by the explicit memorization task.

The studies in the Radulescu et al. framework addressed the effect of input complexity and channel capacity on rule induction. The hypotheses made in this framework and the results obtained by the experiments point out memory and pattern recognition capacity as two key cognitive capacities that constrain or facilitate rule induction. However, as mentioned in section 2.a., attention also plays a part in the learning of artificial grammars. As discussed in the introductory section, mood has an effect on cognition and attention. Therefore, the question arises: if mood has an effect on the attention and cognition, could it ultimately have an effect on rule induction?

2. c. Mood and Rule Induction

As mentioned in the introduction, mood has been proven to have an effect on a very broad range of cognitive processes. Research has shown that in general positive, happy moods are associated with a more global attentional focus and top-down processing, while negative, sad moods lead to a more local focus and systematic, bottom-up processing (Clore & Huntsinger, 2007; Fredrickson & Branigan, 2005). There are two main theoretical approaches which explain this “tree or forest” effect; the first one, the affect-as-information hypothesis by Schwarz and Clore (1983), also mentioned as “affective montage principle” (Clore & Palmer, 2008), states that one’s affective state informs them about the positive or negative value of whatever is in mind at the given time. In many cases, people make evaluative judgments based on their feelings and emotions (such as, evaluating a movie or a meal as good, because it made them feel good).

Taken from simple everyday life applications to processing information as it is presented in cognitive tasks, this effect can be observed in situations where participants have been under a specific mood manipulation, after which they have to solve a task. As Clore & Huntsinger (2007) explain, in such situations a usual strategy is to engage in processing which is related to previous knowledge or beliefs, or in general follow a way of processing which makes use of the most accessible knowledge at the given time. A positive affective state can strengthen this tendency, leading to "interpretive, category-level and global processing", whereas a negative affective state can lower this tendency, leading to "perceptual, item-level and local processing" (Clore & Huntsinger, 2007, p. 394).

In line with this hypothesis, Gasper and Clore (2002) conducted two experiments with image-based tasks in order to investigate the effect of mood on visual perceptual focus. In the first experiment, which followed Bartlett's memory experiments with drawing images (as reported in Gasper and Clore), participants were shown images of an African shield with a title "portrait d' homme" and then had to draw what they saw from memory. Results showed that participants in a positive mood attended to the global aspect and handed in drawings that were more facelike, while participants in a negative mood made drawings that were more focused on local aspects and did not attend to the global features (facelike features and title). In the second experiment, participants were shown sets of images which differed on global and local aspects (e.g., a square made of small triangles). Each set had three images: one target (e.g., a square made of small triangles), and two comparison images (e.g, one triangle made of small triangles, and one square made of small squares). Participants had to decide which one out of two comparison images was most similar to the target one. The images that participants were shown were based on Kimchi and Palmer (1982), experiment 2. The results indicated that participants in a happy mood were more likely to make a choice based on the global, overall aspects of a picture (in our example, they would choose the square made of small squares), while participants in a sad mood were more likely to make a choice based on the local aspects of the picture (in our example, they would choose the triangle made of small triangles). In general, the results confirmed the affect-as-information hypothesis.

A second theoretical approach on the effects of affective states on cognition is the broaden-and-build theory by Fredrickson (1998, 2004)[1] which supports that positive emotions broaden the thought-action repertoires and the scope of attention. The idea is that positive emotions lead to a wider attentional and cognitive breadth, help in the discovery of

[1] Although the broaden-and-build theory refers to emotions, it is included as relevant to the present study, because emotions are discussed in the context of the theory as a general positive "affective state", and specifically mood. This can also be observed by the five basic statements of her theory (see next page), which (at least according to my interpretation) seem more relevant to a state of mood (due to the long-lasting effects they refer to).

one's strengths and limits, and facilitate creativity, while negative emotions narrow the scope of attention and limit the thought-action repertoires. The theory promotes the value of well-being and positive emotional and general health, by five basic statements: a) "positive emotions broaden thought-action repertoires"; b) "positive emotions undo lingering negative emotions"; c) "positive emotions fuel psychological resiliency"; d) "positive emotions build personal resources"; e) "positive emotions fuel psychological and physical well-being" (by Fredrickson, 2004). She provides extensive empirical support for her theory (e.g., significant differences in positive-neutral-negative mood for thought-action repertoires, but not for visual global-local focus (Fredrickson & Branigan, 2005)), for which she claims that the affect-as-information theory does not have explanatory adequacy. However, Fredrickson's theory has also been criticized as not truly empirical but a priori deduced (independently of experience) (Snæbjörnsdóttir, 2010).

Regardless of the theories that attempt to explain these effects, it is important to note that the general effects mentioned above and the link of positive affect - global focus and negative affect - local focus are not are not always consistent, although they are widely observed in experimental research. And even when the effects of positive and negative affect are observed, it is not necessarily true that the elements of cognition in a positive mood, such as broadened attention, are the desired ones: depending on the task, a positive and a negative affect can both impede and facilitate cognitive performance. For instance, in tasks where attention to detail is demanded, a sad mood might help the subjects perform better. According to Schwarz and Bless (1991), positive mood might facilitate a way of processing which lacks logical consistency and attention to detail, and relies on simple heuristics and "rules of thumb", whereas a negative mood facilitates a logical, systematic, step-by-step processing of individual elements, with attention to detail, although significantly lacking creativity.

Similarly, Palfai and Salovey (1993) showed that participants in a negative mood perform quicker in deductive reasoning problems, while participants in a positive mood perform quicker in inductive reasoning problems. The authors conducted experiments with positive, negative, and neutral mood induction (with film clips). The experimental tasks were two reasoning problems (syllogisms), one inductive (analogical) and one deductive (logical). Based on the reaction times of the participants, the results showed that participants in a negative mood had a slower performance than the participants in the other two mood conditions when they had to solve an inductive reasoning task, while participants in a positive mood performed significantly slower in the deductive reasoning task, compared to the participants of the other two mood conditions. We believe that these results can be linked to

Schwarz and Bless' (1991) claim about the differences in processing due to different moods: induction is quicker for participants in a positive mood, as it is easy for them to find the overall patterns, by using simple heuristics; that is not as easy for participants in a negative mood, who follow a systematic and more conservative way of processing, and therefore can perform faster in deductive tasks.

Despite the positive elements of cognition in a negative mood (analytical, systematic reasoning), it appears that negative mood does not facilitate performance in learning and transfer tasks. Transfer of learning refers to the ability to apply knowledge that has previously been acquired to the learning of new tasks and abilities. In Brand et al. (2007), experiments showed that the performance of participants in learning and transfer effects was impeded when participants were in a negative mood. The authors conducted two experiments where participants had to learn how to solve a three- and four-disk Tower of Hanoi, and then solve three more related tasks (five disk Tower of Hanoi, the Missionary and Cannibal Problem and the Katona Card Problem). The learning of solving the three- and four-disk tower of Hanoi was expected to be "transferred" on solving the other three tasks. The positive and negative moods were induced both before the learning of the task (experiment 1), and after that (experiment 2), in order to measure more precisely whether the effect of mood was on learning alone, on transfer alone, or on both. The results indicated that participants in a negative mood were slower, needed more repetitions during learning, and failed to transfer their knowledge as successfully as their counterparts in the positive mood did.

A negative mood does not seem to be assisting syntactic processing either. Vissers et al. (2010) conducted an EEG study in order to investigate whether differences in affective states have an effect on language comprehension, specifically on heuristic and syntactic processing. The authors' hypotheses were that mood could have an effect on language comprehension by increasing or decreasing syntactic processing; or, it could have an effect on language comprehension by increasing or decreasing the use of heuristics, in which case their prediction was that participants in a positive mood would have a higher P600 due to the increased heuristic processing. Participants watched two films (*Happy Feet* and *Sophie's Choice* for positive and negative mood respectively); they were then presented with sentences that did or did not have subject-verb agreement, in order to see whether they would elicit a P600[2]. The results indicated a significant interaction between mood and P600: participants in

[2]P600: an Event-Related Potential (ERP) which is measured by Electroencephalography (EEG). It is typically associated with the processing of syntactic ungrammaticalities, but can also be observed in garden-path

the happy mood condition had a more widespread signal for incorrect verbs (temporal, (temporo)parietal, posterior parietal, occipital and two frontal sites), while participants in the sad mood condition had a significantly reduced P600 for incorrect verbs (only at two posterior sites). In line with their initial hypotheses, the authors give two scenarios to explain these results; first, it could be the case that a negative mood results into a reduced syntactic processing capacity; or second, it could be that the P600 was stronger in the positive mood condition due to the increased heuristic processing, which according to the authors has also been shown to elicit a P600. They propose that "heuristics can also be based on syntactic expectancy", and point out that the relationship between heuristic and syntactic processing needs to be further investigated, and that further research is necessary to indicate what causes a P600 difference in the two mood conditions. As syntactic processing can be related to rule-induction, in the sense that syntax mainly represents the rule-related part of languages, we believe that this study has important implications for the relationship between positive mood, wider use of heuristics, and higher capacity for syntactic processing and (syntactic) rule comprehension, namely, that an increased use of heuristics, which is caused by positive mood, could facilitate syntactic processing.

Lastly, apart from Gasper and Clore (2002), the effect of mood on visual focus was also tested by Bertels, Franco, & Destrebecqz (2012), who investigated the effect of neutral and sad moods on visual statistical learning. The results did not show any significant differences between the two groups; however, the participants in the negative mood showed a more explicit awareness of the rules underlying the visual patterns, compared to the neutral mood group.

How are the topics discussed above linked to rule induction? These studies provide evidence that mood has an effect on inductive reasoning, learning, problem solving, transfer effects, syntactic processing, and visual focus. These issues are linked to artificial grammar learning and rule induction, as this is a process which requires inductive reasoning, learning skills and encoding of new stimuli, and it is based on transfer effects, as it relies on general learning mechanisms that we have from knowing other languages, such as syntactic processing. Nevertheless, research investigating the effects of mood or emotions on artificial grammar tasks has so far been a bit neglected. This is mainly due to the following reasons; first, the Chomskian perspective for the Language Faculty describes a very robust system which, unless there is a serious abnormal development of the system, or brain injury, is

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sentences and long distance *wh*-dependencies (Gouvea, Phillips, Kazanina, & Boevel, 2009).

supposed to function regardless of other issues, such as emotional differences. In this framework, which has been dominant for many decades in the linguistic research, the acquisition of syntactic structures is considered to be a robust and mechanistic procedure. Second, a similar approach was adopted by the theorists of implicit statistical learning (which is the learning mechanism of artificial grammars); the evolutionary theory developed by Reber (1992, 1993) stated that implicit, unconscious cognitive processes are unaffected by affective states, compared to explicit, conscious cognitive processes. In addition, people are not expected to have significant individual differences in their performance in implicit learning tasks, since it is a robust, unconscious system encoded in every normally developing individual.

Due to this bias against emotional states and their potential effects on learning of artificial grammars, there has been only one study (to the best of our knowledge) which investigated, among other cognitive tasks, the effect of mood on artificial grammar learning. Trotz, Pretz, and Kaufman (2010) conducted experiments to explore the effects of mood, cognitive style, and cognitive ability, on implicit learning. They employed the Rational Experiential Inventory (REI) scale to measure cognitive styles. The measures of REI were on four categories: rational ability, rational favorability, experiential ability, and experiential favorability; the term “ability” refers to the extent to which they actually use their rational or experiential abilities, and the term “favorability” refers to preference of rational or experiential way of thinking. The authors further tested the participants on four standardized tests (on English, Mathematics, Reading, and Science, which measured abilities such as problem solving, critical thinking, and reasoning in these subjects); these tests were used to measure cognitive ability. The mood manipulation was achieved by having participants view photographs (according to positive, negative, or neutral mood condition). They were then tested on two implicit learning tasks, a Serial Reaction Time task (SRT), and an artificial grammar task (AG). The results indicated that mood did not have a significant effect on the SRT task; REI had a significant effect on the AG task, but not on SRT. The tests on cognitive capacities only indicated a significant effect on SRT, and specifically for the Mathematics test; no significant effect on AG was found.

Here we are focusing on the AG task, as the point of our interest. The authors hypothesized that a positive mood would facilitate the learning of the AG, while a negative mood would impede this process. They expected that participants in a negative mood would have the lowest performance, compared to participants in the two other groups. The participants were instructed to memorize 20 exemplary strings during the training phase.

After that, they were tested with 26 grammatical strings (7 from the original set and 19 new ones), and 24 ungrammatical strings. The results indicated that negative mood facilitated the artificial grammar learning, therefore the negative mood's group performance was the highest, compared to the two other groups. The authors explain this result, which is contrary to their initial hypothesis, as an effect of the enhanced bottom-up, systematic processing that participants in a negative mood exhibit; according to them, this type of processing might have facilitated the performance of the sad participants, compared to the participants in the two other groups, because of the deeper, more detailed, and more systematic type of processing. However, we need to note here that the explicit instruction of memorization might have caused these results: as we saw in this section, individuals in a bad mood tend to focus more on items, and rely more on familiar stimuli. This which might have helped them in the process of memorizing items, thus making them able to identify the grammatical strings more easily, compared to the other groups' participants. Another issue was the large number of test items (26), which might have had learning effects on the participants. These methodological "question marks" lead us to believe that the results might have been an artefact of the instructions and methodology, and not of the mood effects on artificial grammar learning.

Summarizing, there is a widely observed effect of the affective states (either mood or emotions) on the way of one's processing and focus. Two different theories have attempted to explain these effects: the affect-as-information hypothesis and the broaden-and-build theory. Experimental evidence has shown that visual focus, learning abilities, reasoning, transfer effects, and syntactic processing are affected by the different states of mood and emotions. However, despite the link between these subject areas and rule induction in language, there is not enough research conducted on the effect of mood on artificial grammar learning and rule induction; the paper by Trotz et al. (2010) presented certain methodological issues, which pose the results under question; hence, the theoretical gap in the research of mood and rule induction remains.

3. Research Questions and Hypotheses

The present study investigates the effect of mood on rule induction, by following the hypotheses formed by Radulescu (2014) and Radulescu et al. (submitted), and adding the component of mood. We hypothesize that one's affective state will have an effect on the type of processing and attentional focus during the learning process, which ultimately has an effect on rule induction. We assume that an individual in a negative mood will adopt a more conservative way of processing; it is expected then that there will be a higher reliance on memorization, which will lead to item-bound processing and a lower tendency of inducing a general, category-based rule. When, on the other hand, the mood is positive, there will be a tendency to rely on simple heuristics, which will help the participants in a positive mood to identify the general pattern of the artificial grammar and achieve the induction of the general, category-based rule.

The main research question of the present study is: what is the effect of mood on rule induction?

And more specifically:

a. Will participants in a negative mood have a lower performance in the rule induction task, compared to the participants in a positive mood?
b. Is the effect of mood observed in general focus, or can it be observed in specific tasks only?

The study will adopt the following hypotheses:

i) A negative mood results in a more systematic and item-level cognitive processing, with a higher tendency for memorization and higher attention to details. Therefore, during the learning process of the artificial grammar, participants in a negative mood will have a higher tendency to rely on their memorization capacity and focus on the details. This tendency will function as a temporary increase of the channel capacity, and specifically of memory capacity; thus, according to the hypotheses of Radulescu et al. (submitted), the higher channel capacity will lead to a higher tendency for item-bound generalizations, and a lower tendency for category-based generalizations.

ii) A positive mood results in a more global and category-level cognitive processing, with higher reliance on simple heuristics and attention to the "general picture". Due to this type of processing, individuals in a positive mood will have a higher tendency to identify the general rule of the artificial grammar, and therefore to induce a category-based generalization, compared to the participants of the negative mood condition.

iii) For the global-local visual perceptual task, we expect participants in a negative mood to give more responses based on the local aspects of the images, while participants in a positive mood will have a higher tendency to respond based on the global aspects of the images (replicating the results by Gasper & Clore, 2002).

In order to test our hypotheses we performed an experiment where the participants' mood was manipulated; after that, they had to solve a rule induction and a visual perceptual task. Following Gasper and Clore (2002), we assumed that there would be no significant differences between participants in a positive mood and participants in a neutral mood, which is why we only tested groups of participants in a positive and negative mood. The methodology of the experiment is described in the next section.

4. Methods

4. a. Participants

The experiment was approved by the Ethics Committee of the UiL-OTS. It was conducted with 46 healthy, non-dyslexic Dutch speaking women (age range 19-55, M=23.8, SD=7.57). They were randomly assigned in two groups (positive or negative mood group), so that each group would include 23 participants. 48 participants were tested in total, but 1 participant was excluded from the analysis, because she reported familiarity with artificial grammars. Another participant was excluded because she seemed unable to fully understand the tasks' instructions and perform well during the experiment. All participants signed a form of consent and were paid 6 Euros for their participation.

We chose to recruit only female participants because we wanted the mood induction to be as realistic and successful as possible. We assumed that the material used for the mood induction (film clips), in particular *Sophie's Choice*, would be more effective in female population.

4. b. Materials

i. Positive and Negative Affect Schedule

Before the beginning of the experiment and after watching the film fragments, participants had to rate the extent to which they experience each one of 10 positive and 10 negative emotions, on a scale from 1 to 5. They did this through a Dutch adaptation of the Positive and Negative Affect Schedule (PANAS) (Watson, Clark, & Tellegen, 1988). The questionnaire can either be filled in according to the participants' weekly, or momentary affect. We asked the participants to fill it in according to their momentary affect ("Indicate to what extent you feel this way *right now*, that is, *at the present moment*"), as we wanted to assess the differences in the affective states before and after the mood manipulation. The PANAS has two different measurements for Positive Affect and Negative Affect, each of which can range between 10-50 points.

ii. Rule induction task

The first task was an artificial grammar task measuring rule induction capacity, named *Words from a Forgotten Language*. The task was previously used in Radulescu et al. (submitted) for the same purpose. We used the Low entropy condition (2.8 bits - as in experiment 2 of Radulescu et al.), the exact same training items and instructions.

The task was written in a ZEP script. The artificial grammar had an XXY pattern, 3 syllable strings where X and Y represent syllables (consonant + long vowel) which resemble the Dutch phonology (e.g., teu, sjie). The XXY strings were generated with a Perl script and checked in the Celex database, to ensure that they do not exist as actual words or morphemes of the Dutch language. The recordings that were used were the ones already available from the previous experiments performed in Radulescu et al. (submitted). The entropy condition was the Low one (4*7 X/4*7 Y; 7 strings following the rule XXY were repeated 4 times in each training phase). This particular condition of entropy was chosen as previous experiments by Radulescu et al. have shown that in this condition there is higher variation in the results, compared to the other two. Participants were exposed to the same 28 strings of XXY pattern in each training phase. After each training phase there was a test phase, and after the third test there was a last final test. The tests' question was "could this string be possible in the language you heard before?". In total, the participants would have 4 test items in each test phase, except for the last test phase where they had 8 test items; they would hear 5 variants for each test type of string, as there were 4 tests in total, and the last test was a double one (5* XXY trained, 5* X1X2Y trained, 5* XXY untrained, 5* X1X2Y untrained).

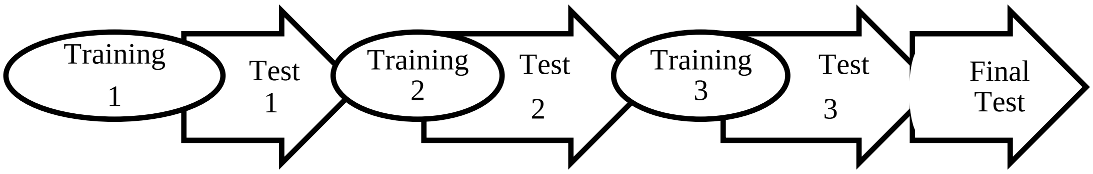

Figure 2: Rule induction task. Description of process (by Radulescu et al., submitted).

ii. Global-Local Visual Perceptual Task

The second task was the Global-Local Visual Perceptual Task, which measured the participants' visual focus (following Gasper and Clore (2002)). Participants were seated in front of a screen, with a button box in front of them. They were presented with 14 sets of three images. To illustrate the structure of the task: one "target" image was at the top of the screen (e.g., a square made of small triangles), and two comparison images were at the bottom of the screen; one was similar to the target image on a local aspect (i.e., made of small triangles) but differed in the global aspect, and the other one was similar to the target pattern on its global, overall shape (i.e., a square), but not on its local aspect. Participants were instructed that they had to choose which one of the two comparison images on the bottom of the screen is most similar to the target image on the top of the screen. They were told that they had to make a decision as soon as possible, by pressing on the button of their preference (left button for the left image, and right button for the right image). First, they had a small trial phase with 2 sets of images, after which they had the chance to ask the experimenter any further questions. They could then proceed to the main task.

The task was written on a ZEP script. The images were taken by Kimchi and Palmer (1982), experiment 2; they varied in size and number of parts (there could be images consisting of a only a few squares or triangles, or consisting of many more). In order to avoid any biases due to size, the order of the images was randomized, so that participants would see images of any size and any consistency in a random order. The measurement was made on a scale from 0 to 14, with 0 representing answers focusing on local characteristics only, and 14 representing answers focusing on global characteristics only; thus, a score of 14/14 would indicate that the participant focused only on the global aspects of the images, and a score of 0/14 would indicate that the participant focused only on the local aspects of the images.

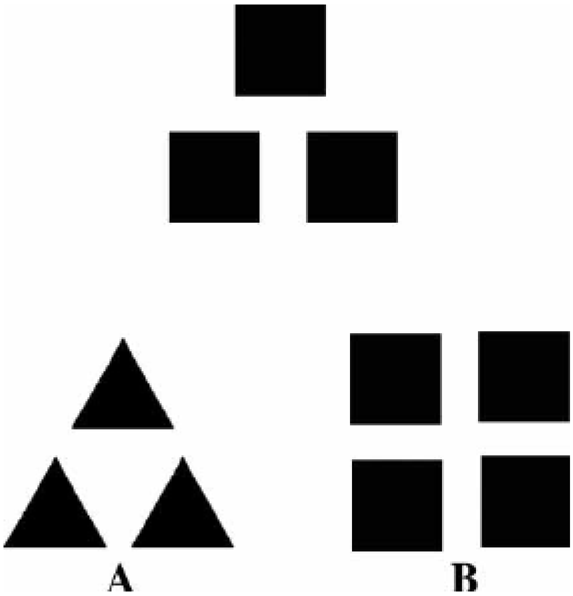

Figure 3: Image from the Global-Local Perceptual task by Kimchi & Palmer (1982)

iii. Feedback Form

At the end of the experiment, the experimenter asked the participants a few questions, in a feedback form. The questions were the following:

1) How did you feel after watching the movie? Did it change the way you felt, compared

to when you came in the lab?

2) In the task *Words from a forgotten language*, did you use a strategy to answer during the tests?
3) How did you make your choices for the task with the images?
4) On a scale from 1-5 (1 being the least and 5 being the most), how much do you get involved with the feelings of a character in a novel/movie?

4. c. Mood Manipulation

Depending on their group condition (positive or negative), participants had to watch short film clips from two movies: *Happy Feet* for the positive mood condition and *Sophie's Choice* for the negative mood condition. They were seated in front of a screen, with two speakers on either side of them. The film clips consisted of 5 fragments (3 or 4 minutes each), which were bound together in one film clip of 20 minutes. The fragments were selected in order to be maximally happy or sad and have a relative coherence.

4. d. Procedure

The experiment took place in the UiL-OTS laboratories in Utrecht. The participants had to fill in a PANAS questionnaire as their first task. After that, they were informed that they are going to watch a 20-minute clip of a film depending on their condition. The experimenter would then take the first PANAS questionnaire and leave another one in the booth, and ask the participants to fill it in after they watched the film. The order of the two main tasks was counterbalanced, in order to avoid any bias; half of the participants from both groups performed the Rule Induction Task first and the Global-Local Visual Perceptual Task second, and the other half of the participants performed the tasks in the opposite order. At the end of the main tasks, the experimenter asked the participant a few questions in a Feedback Form.

The Rule Induction Task consisted of three training phases, each of which was followed by a test phase. It ended with a final test. Participants were seated in front of a screen, with a button box in front of them and two speakers on either side of them. They were told that they were about to hear words from a forgotten language, which is unknown to them, and has its own rules and grammar. They were informed that there are more words than those they listen to during the training phases, and that there are going to be 3 training phases and 4 test phases. During the test phases they would have to decide if the strings they hear could be possible in the language they heard before or not, and press the button yes or no respectively.

4. e. Test Types and Performance Predictions

In order to have a clear perception of the Rule Induction Task's test types, and of what exactly is expected to be found by the experiment, this section will outline the performance predictions for each one of the two main tasks (Rule Induction and Global-Local Visual Perceptual Task).

i) Rule Induction Task

Participants will be tested with strings of four types during each test phase. The performance predictions of both groups for each type of string are given below. This section resembles the section of Radulescu et al. (submitted), but the exact expectations here are adjusted according to the different mood conditions.

- Type 1 (XXY trained); a grammatical XXY string that was among the strings that participants listened to during the training phases (correct answer-yes). It obeys the grammatical XXY pattern, and it consists of syllables that participants heard during the training phase. Therefore, regardless of the type of rule generalization that participants have formed, they are expected to accept this string, as it has the general, grammatical XXY pattern (category-based generalization), but it is also a string familiar to the participants from the training phase (item-bound generalization) (Radulescu et al., submitted). Therefore, we expect participants from both mood conditions to correctly accept this string.
- Type 2 (X1X2Y trained); the string does not obey the grammatical XXY pattern, but consists of syllables that participants heard during the training phase; X1 and X2 differ from each other, but they both come from the "pool" of X syllables (correct answer-no). We expect that both groups will have a high tendency to reject this string; however, we expect that participants in a positive mood will reject this string more than participants in a negative mood, because of their higher tendency to induce a category-based rule; on the other hand, participants from the negative mood group might be more prone to falsely accept it, because it has familiar syllables.
- Type 3 (XXY untrained); grammatical strings consisting of new syllables (not presented during the training phase) (correct answer-yes). This type of string is the main target, as it shows whether participants managed to induce the general, category-based rule and apply it to novel items (Radulescu et al., submitted). We expect that the participants of the positive mood group will have a higher tendency to correctly

accept this string, compared to participants in a negative mood, because they will have a higher tendency for category-based rule induction.

- Type 4 (X1X2Y untrained); ungrammatical strings consisting of new syllables (correct answer-no). This is a type of string which we expect to be rejected by the participants, regardless of the type of rule they have induced (item-bound or category-based) (Radulescu et al., submitted). It does not obey the grammatical XXY pattern, so it should be rejected by individuals that have formed a category-based generalization (in the positive group), and it does not have familiar stimuli (syllables) from the training phases, so it should also be excluded by individuals who memorized the stimuli (negative group). Therefore, we expect both groups to correctly reject this string.

ii) Global-Local Visual Perceptual Task

We expect that the results will roughly replicate the results by Gasper and Clore (2002): participants in a positive mood will give more answers based on the overall, global features of the images, while participants in a negative mood will give more answers based on the local aspects of the images. Based on the scale of 0-14, with 14 being a perfectly "global" response and 0 being a perfectly "local" response, the mean performance of the positive mood group is expected to be higher than the negative mood group's.

4. f. Analysis

We first had to assess whether the participants had changes in their moods after the mood manipulation, and also test whether the two groups of the participants differed significantly *before* the mood manipulation in their moods, in order to avoid any bias. For these purposes, we used a paired samples t-test to see whether the differences in the mood *within* each group (before and after the mood manipulation) were significant, and two independent samples t-tests, in order to see whether the differences in the mood *between* the two groups (before and after the mood manipulation) were significant.

For the analysis of the two main tasks (Rule Induction Task and Global-Local Visual Perceptual Task) we performed Generalized Linear Mixed Models (binomial logistic regression). We built the model for the Rule Induction Task by keeping the same target (Accuracy) and adding the factors one by one. We started by adding the random factors, Subject (participant id) first, and after that Item. We continued by adding the fixed factors: first we added Mood Condition (group) as fixed factor; we did not expect an overall effect of the mood condition on the performance of the participants, but rather an effect of mood on the performance for specific Types of Strings. Therefore, we then added the interaction of Type of String x Mood Condition as a fixed factor, because we wanted to look into this particular interaction; as mentioned before, there were specific predictions for specific types of strings, according to each group. Based on the mood condition, we expected a different type of rule generalization to be formed, which would lead to a different performance for each group. We did not use Type of String as a fixed factor on its own, because it would not be informative; even if we had significant results for specific types of strings, we would not know what exactly that would mean for our hypotheses, because it would not reveal anything about the mood's influence on rule induction. Similarly, we then added Test x Mood Condition interaction as another fixed factor, because we wanted to see whether each mood condition (group) would react differently as the tests proceeded. Essentially, the two interactions of Type of String and Test with Mood Condition were used as fixed factors, as the main hypothesis of the present paper predicted differences in the performance for specific types of strings (Type 2 and Type 3) *because* of the different mood conditions. Lastly, the Order of Tasks was added as a fixed factor, in order to see whether performing the two main tasks in a different order (Rule Induction Task first and Global-Local Visual Perceptual Task second, or the opposite order) would affect the participants' performance. The overall goodness of fit improved after the addition of each factor and reached up to 91%.

For the second main task (Global-Local Visual Perceptual Task) we built a simpler model, as we did not have specific predictions for any of the items presented. We expected an overall effect by the mood condition, namely that participants in the positive mood group would have a higher overall performance compared to the negative mood group (since the coding of the answers was 0 for local response and 1 for global response, and we expected that participants in a positive mood would have a more global focus, compared to participants in a negative mood). We built the model for the Global-Local Visual Perceptual Task by keeping the same target (Response (global/local answer)), and adding the factors one by one. We started by adding the random factors, Subject (participant id) first, and after that Item. We continued by adding the fixed factors one by one: the first one was Mood Condition (positive/negative mood group), the second was Order of Items (the order in which the images were presented), and lastly Order of Tasks (Rule Induction and Global-Local Task). The addition of each fixed factor improved the overall goodness of fit of the model, which reached up to 84%.

5. Results

i) Mood manipulation check

In order to assess the mood manipulation efficiency, and the difference of mood between the positive mood group and the negative mood group, the participants had to fill in the PANAS (Watson, Clark, & Tellegen, 1988). The Positive Affect and the Negative Affect were assessed individually, and can each have a score of 10-50. The table below gives mean scores of the Positive and Negative Affect for each group before and after the mood induction.

Table 1. *Positive and Negative Affect means before and after the mood induction.*

	Positive Group		*Negative Group*	
	P.A.*	N.A.*	P.A.	N.A.
Before M.I.*	M=31.35, SD=5.83	M=13.48, SD=3.32	M=29.78, SD=6.17	M=13.22, SD=.64
After M.I.	M=33.17, SD=6.31	M=10.48, SD=.79	M=22.39, SD=5.5	M=21.48, SD=1.28

*P.A=positive affect, N.A.=negative affect, M.I.=mood induction.

According to Watson et al. (1988), our sample is within norms for the momentary PANAS scores (P.A. mean score=29.7, *SD*=7.9; N.A. mean score for women=14.8, *SD*=5.4).

A paired samples t-test was performed to assess the efficiency of the mood manipulation. We used an alpha level of .05. For the positive group, the scores of the P.A. were not significantly higher ($t(22)=-1.595$, $p=.12$), and the scores of the N.A. were significantly lower ($t(22)=4.25$, $p < .001$) after the mood induction. For the negative group, the scores of the P.A. were significantly lower ($t(22)=7.13$, $p< .001$), and the scores of the N.A. were significantly higher ($t(22)=-6.65$, $p < .001$) after the mood induction.

We further performed an independent samples t-test to assess whether the two groups differed in terms of P.A. and N.A. before the mood induction. An alpha level of .05 was used for all statistical tests. No significant differences were found ($t(44)= 0.88$, $p =.38$ for the P.A. and $t(44)= 0.26$, $p =.79$ for the N.A.). The same test was used to compare the means of the two groups' PANAS scores after the mood manipulation. The P.A. of the positive group was significantly higher than the P.A. of the negative group ($t(44)=6.17$, $p < .001$), and the N.A. of the negative group was significantly higher than the N.A. of the positive group ($t(44)=-8.47$, $p < .001$).

ii) Rule Induction Task

In order to test the effect of mood on rule induction, the two different mood conditions were compared in a Generalized Linear Mixed Model (using SPSS version 23), with Accuracy (correct acceptance/rejection) as dependent variable, Mood Condition (positive/negative mood group), Type of String x Mood Condition interaction, Test x Mood condition interaction, and Order of Tasks (Rule Induction and Global-Local Task), as fixed factors. Subject (participant id) and Item were added as random factors. An alpha level of .05 was used for all statistical tests.

There was a statistically significant Type of String x Mood Condition interaction ($F(6, 903)=9.847$, $p< .001$). There was no statistically significant main effect of Mood Condition ($F(1, 903) = 1.525$, $p=.217$), no statistically significant Test X Mood Condition interaction ($F(8, 903) = 1.296$, $p = .242$), and no statistically significant effect of Order of Tasks ($F(1, 903) = 0.033$, $p = .856$).

The table below shows the mean correct responses for both groups. An excellent performance would be indicated by 1.0, therefore the numbers below can also be interpreted as percentages (.98=98%, .87=87%, and so on).

Table 2. *Mean correct responses for both groups. M=Mean, SD=Standard Deviation*

	Positive Group		Negative Group	
String Type	M	SD	M	SD
1 (XXY trained)	.98	.05	.94	.12
2 (X1X2Y trained)	.87	.22	.80	.32
3 (XXY untrained)	.76	.26	.67	.35
4 (X1X2Y untrained)	.97	.06	.93	.14

No statistical significance was found for the performance on Type 1 (XXY trained), for neither of the groups. The analysis indicated a statistically significant performance for Type 2 (X1X2Y trained) for both mood conditions ($t(39) = 2.77$, $p = .006$, for positive mood, and $t(39) = 2.95$, $p = .003$ for negative mood). A statistically significant performance was also found for Type 3 (XXY untrained) for both mood conditions, ($t(39) = 4.09$, $p < .001$, for positive mood, and $t(39) = 54.92$, $p < .001$, for negative mood). Lastly, no statistical significance was found on the performance for type 4, for neither of the groups.

iii) Global-Local Visual Perceptual Task

In order to test the effect of mood on visual focus, the two different mood conditions were compared in a Generalized Linear Mixed Model (using SPSS version 23), with Response (global/local answer) as the dependent variable, Mood Condition (positive/negative mood group), Order of Items (the order in which the images were presented), and Order of Tasks (Rule Induction and Global-Local Task) as fixed factors. Subject (participant id) and Item were added as random factors. An alpha level of .05 was used for all statistical tests.

Table 3 illustrates the two groups' responses. The measurement indicates responses based on the images' global aspect (14/14 indicates responses based exclusively on global aspects of the images, and 0/14 indicated responses based exclusively on local aspects of the images).

Table 3. *Means for both groups. M= Mean, SD=Standard Deviation.*

Group	M	SD
Positive	9.13	5.18
Negative	8.65	4.12

There was no statistically significant main effect of Mood Condition ($F(1, 628) = 0.30$, $p = .57$), no statistically significant effect for Order of Items ($F(13, 628) = 1.13$, $p = .32$) and no statistically significant effect of Order of Tasks ($F(13, 628) = 1.09$, $p = .29$).

iv) Feedback Form

The questions of the feedback form are repeated below in italics. We did not perform a statistical analysis of the results, as the feedback form only has an explanatory role for the data obtained by the main tasks of the experiment and the mood manipulation.

1) *How did you feel after watching the movie? Did it change the way you felt, compared to when you came in the lab?*

Participants in the positive mood condition who watched clips from *Happy Feet* differed in their responses: 12/23 reported that they felt happier and more positive after the movie (52.17%), but 11 participants (47.82%) reported that the movie did not affect them that much (using phrases such as "not really" or "only a little bit"). All of the participants in the negative mood condition who watched clips from *Sophie's Choice* reported that the way they felt changed (19/23 used the adjective "sad" (82.6%). 2 other participants felt "angry" and 2 felt "sad and ashamed" (17.4% in total)).

2) *In the task Words from a forgotten language, did you use a strategy to answer during the tests?*

19/23 (82.6%) of the participants in the positive mood condition reported that they identified the underlying grammatical XXY pattern ("same-same-different"). 3 participants of the same group reported that they tried to memorize the words (13.04%), and 1 participant responded that she answered intuitively (4.34%). In the negative mood condition, 8/23 (34.78%) participants reported that they identified the grammatical XXY pattern; 2 participants reported that they first used their memory, and then identified the grammatical XXY pattern (8.6%). The rest of the participants in the negative group (13/23) reported that they focused on the details of the words, such as vowels, and that they tried to memorize the words during the training phase (56.5%).

3) *How did you make your choices for the task with the images?*

Since the participants of the two groups performed almost equally in this task (M=9.13 for the positive group and M=8.65 for the negative group), we report the responses of all the participants, regardless of their groups.

19/46 participants responded that they gave their answers based on the global aspect only (overall shapes of the images) (41.3%). 3 participants reported that they gave their answers based on the local aspect only (small features) (6.5%). From the remaining participants, 11/46 reported that they answered intuitively (23.9%), and 14 of the participants reported that they started with a specific strategy (attention to global or local characteristics), but after a few images they switched to the other aspect (30.43%).

4) *On a scale from 1-5 (1 being the least and 5 being the most), how much do you get involved with the feelings of a character in a novel/movie?*

22 participants responded with "4" (a lot) (47.82%); 10 of the participants were from the negative group and 12 from the positive group. 11 participants responded "3" (average) (23.91%); 6 of them were from the negative group and 5 from the positive group. 8 participants responded "5" (the most) (17.39%); 4 were from the negative and 4 from the positive group. 4 participants responded "2" (a little bit) (8.69%); 3 were from the negative and 1 from the positive group. Lastly, 1 participant from the positive mood responded "1" (the least-not at all) (2.17%).

6. Discussion

In this experiment we performed mood manipulation, after which we examined the participants' rule induction capacity and visual focus. The results showed that mood manipulation was overall successful, that there was an effect of mood on rule induction, and that there was no effect of mood on visual perceptual focus.

There was no significant difference between groups in terms of their Positive and Negative Affects *before* they watched the experiment films. Hence, there was no bias in terms of one group being in a better or worse overall mood. Nevertheless, the groups differed significantly in their affect *after* watching the films: the Positive Affect of the positive group was significantly higher than the Positive Affect of the negative group. We can then safely conclude that the two groups consisted of people with significantly different moods. For the negative group, the scores of the Positive Affect were significantly lower, and the scores of the Negative Affect were significantly higher after the mood induction, therefore, the mood induction was fully successful. However, for the positive group, the scores of the Positive Affect were not significantly higher, and the scores of the Negative Affect were significantly lower after the mood induction. It seems then that the movie did not succeed in putting the participants into a much more positive mood, although it did reduce their negative affect. This can be explained by the participants' responses in the feedback form, where almost half of the positive group's participants reported that the movie *Happy Feet* did not significantly change the way they felt, but only affected them to a small degree; we assume that this might have happened because the participants of the positive mood group did not identify or empathize with the main character of *Happy Feet* as much as participants the negative mood group did with *Sophie's Choice*. However, this is not a problem for our study, as the two groups were eventually different in their affective states.

The overall success in mood manipulation allows us to address the main objective of this study, which was to test the effect of mood on rule induction. The results of the Rule Induction Task show that the mean acceptance of the new grammatical XXY strings (Type 3) differed between the two groups: the negative group had a lower mean acceptance, while the positive group had a higher mean acceptance. A difference in the two groups' results was also demonstrated in X1X2Y trained (Type 2) strings: the mean correct rejection of the string was higher in the positive group, compared to the negative group. Interestingly enough, the participants' reports in the feedback forms confirm these tendencies; almost all of the participants in the positive mood condition identified the general XXY rule of the grammar, while less than half of the participants in the negative mood condition did so. On the contrary, more than half of the negative group's participants reported that they relied on memorization and focused on the details, in order to answer during the test phases. These results are according to the hypotheses and performance predictions; indeed, as we hypothesized, participants in a negative mood relied more on memorization and details, hence forming an item-bound generalization, while participants in a positive mood relied more on simple heuristics and identified the general pattern of the grammar, thus forming a category-based generalization.

An issue that requires further investigation is the direct effect of mood on the capacities that constitute the channel capacity (memory and pattern recognition); the results of the present study might be explained due to differences in cognitive processing caused by the different conditions of mood, which also implies (temporary) differences in the channel capacity. In our initial hypotheses, we stated that the item-level and detailed processing of a negative mood, with focus on the details and memorization, functions as a temporary increase of the channel capacity (memory); the results might be explained by this hypothesis, but the direct effect of mood on memory is not tested through the present experiment. In addition, we cannot have clear insights about pattern recognition capacity (as described in Radulescu et al., submitted), as it is a complex problem-solving task which could theoretically be facilitated both by a positive and a negative mood; a positive mood could cause higher use of simple heuristics, therefore it could lead to a quicker induction of the pattern's rules, while a negative mood, which usually leads to more systematic and detailed processing, could also lead to a safe identification of the pattern's underlying rules. Therefore, we suggest that further research should be conducted on the effect of mood on memory and pattern recognition, in order to have a more concrete idea of what the effect of mood on channel capacity is.

The results of the Rule Induction Task are in line with the results of Tanaka et al. (2008) and López-Barroso et al. (2016): indeed, attention plays a crucial role in the learning of artificial grammars, as the results indicated in the present study. In the present study, the differences in the attention and type of processing of the participants according to their mood lead to differences in the mean performance. The results of the present study are however contrary to the results of the study which had investigated, among other topics, the effect of mood on artificial grammar learning (Pretz et al., 2010, discussed in section 2. c.). However, as discussed in 2. c, this difference can be explained due to the different methodology and instructions that were used in the Pretz et al. (2010) study; the authors instructed the participants to memorize the strings of the artificial grammar, which might indeed have given an advantage to participants in a negative mood as they are more prone to memorization and focusing on details (according to the "affect-as-information" hypothesis and extensive previous research, as discussed in 2. c, and the participants' reports in the present study).

Additionally, we believe that the results in the Rule Induction Task confirm the affect-as-information hypothesis (Clore & Huntsinger, 2007); indeed, participants in a negative mood demonstrated and reported a more item-level, local and detailed type of cognitive processing, while participants in a positive mood identified the primed and more accessible XXY pattern and demonstrated a category-level, global type of processing, with attention to the "general picture". Regarding Fredrickson's broaden-and-build theory, we agree with Snæbjörnsdóttir's (2010) criticism about its a priori nature, in the sense that the theory seems hard to test with an experimental task (and therefore, hard to accept or reject based on observation). The theory refers to positive emotions contributing to "general well-being", "psychological resiliency", "undoing negative emotions"; it seems impossible to test and prove these assumptions with tasks such as the Rule Induction Task and the Global-Local Visual Perceptual Task; considering the fact that Fredrickson has used the latter task in an attempt to prove her hypothesis (Fredrickson & Branigan, 2005), this is a problematic point for the broaden-and-build theory.

The participants' responses with respect to their strategy during the test phases pose another issue. According to Reber (e.g., 1967), artificial grammars are learned in an exclusively implicit way, without explicit knowledge of the rules. Nevertheless, in the present study, more than half of the participants reported explicit awareness of the underlying rules of the grammar. In addition, Reber (e.g., 1992, 1993) proposes that in implicit learning of tasks no significant individual differences are to be found, because the mechanism of implicit learning is robust, and it is not affected by factors that affect explicit learning processes (such as external factors), or by individual differences in the affective states. However, differences among groups can be found in studies with different entropy conditions (Radulescu et al., submitted), and different mood conditions, such as in the present study, Pretz et al. (2010), and Bertels et al. (2012), in visual statistical learning. This implies that psychological and other individual differences might affect implicit learning, or make it a more conscious process. Since there are results that pose the implicit nature of tasks such as artificial grammar learning under question, we suggest that artificial grammars are not purely implicit tasks, and even if the learning of artificial grammars occurs implicitly, the knowledge can become explicit.

The results for the Global-Local Visual Perceptual Task reject our initial hypothesis; regardless of their mood condition, most of the participants reported to have chosen a consistent strategy in order to answer (based on either the global or the local features of the pictures). A number of participants also reported starting with a specific strategy (e.g, responding based only on the global aspects of the images), and then switching to the opposite, which explains why the order of the images appeared to be significant for specific cases. The participants followed the same instructions as Gasper and Clore (2002), therefore we do not believe that this result is due to false instructions. However, the result could be attributed to the use of different images than in Gasper and Clore (2002); we used the same images as in Kimchi and Palmer (1982), which had many different sizes and consistencies, and thus did not prime any type of focus (global or local). We do not know which exact images Gasper and Clore (2002) chose for their experiment.

Based on these results, a further hypothesis of the present study is that the effect of mood might be more consistently demonstrated in deeper cognitive processes, such as rule induction (present study), reasoning (Palfai & Salovey, 1993), learning and transfer (Brand et al., 2007), and syntactic processing (Vissers et al., 2010). The Global-Local Visual Perceptual Task, on the other hand, did not require elaborate processing and reflection on knowledge acquired, but was simply a task which asked for the participants' preference. Note, in addition, that Fredrickson and Branigan (2005) also found no significant differences among neutral, positive, and negative mood groups for this specific task. We believe then that the inconsistency of results in the Global-Local Visual Perceptual Task (Fredrickson & Branigan, 2005; Gasper & Clore, 2002; present study) can be explained due to the inconsistent effect of mood on *superficial* attention and focus. Of course, further research is necessary, in order to confirm this hypothesis.

On a final note, we should mention that the test items of the Rule Induction Task (5 different items for each type of string (5 tests[3] x 4 types of strings=20 strings in total)) might not have been sufficient to form a very robust statistical model. In addition, as reported above, there were still participants in the negative mood condition who demonstrated a perfect performance and identified the grammatical XXY pattern. Lastly, the number of participants (46, 23 for each group) might be a bit less than sufficient as a sample in order to get robust conclusions (around 30-40). These issues suggest that even though there were clearly significant results and most of the participants reported to have used strategies in line with the initial hypotheses, these results should still be taken with a grain of salt.

7. Conclusion

The present study investigated the effect of mood on rule induction capacity and visual perceptual focus. The results indicated that rule induction is impeded by negative mood, and facilitated by positive mood. We conclude that the effects of mood are not observed overall in the attention and cognitive processing of individuals, but are demonstrated mainly in tasks which require more elaborate processing. Research on mood and its effects on our cognition remains a challenge, mainly in its methodological aspect, as there is still the necessity for realistic and life-like mood manipulation in experimental environments.

In any case, as mentioned above, the effect of mood is not absolutely robust; and without a doubt, individual differences also play a major role in one's cognitive abilities and attention. Nevertheless, as an application to educational and general learning environments, we suggest that encouraging positive environments might facilitate learning processes, and that individual mood differences should always be taken into account. This is an issue both for children and adult (second) language education, and it is extremely relevant in today's world, where populations move all around the globe (either by force or by choice) and have to learn new languages quickly and effectively.

On a final note, we suggest the following ideas for future research:

a) Investigate the effect of mood on the components of channel capacity (pattern recognition and incidental memorization). This could give us better insights about the effect of mood on the channel capacity itself, and not indirect measurements for the channel capacity, as the present study. We could then have a complete account about the effect of mood on rule induction and channel capacity.

[3] Here we refer to 5 tests x 4 types of strings. As mentioned in the Methods section, there are 4 test phases in the Rule Induction Task. The final, fourth test has 8 test items instead of 4 (2 different items for each one of the 4 types of strings). Therefore, we refer to 5 tests because we count the fourth test as two tests.

b) Use an artificial grammar with non-adjacent rules (AXC) and test the effect of mood on rule induction. The XXY pattern that was used in the present study is rather easy, and therefore the positive mood group performed better in the task and identified the general rule to higher extent than the negative mood group. Will these results be replicated when an artificial grammar has a more complicated structure? Or will the higher reliance on simple heuristics not facilitate the process of learning complex structures, but rather a more systematic, conservative approach will do, as the one that individuals in a negative mood adopt?
c) Test the effect of mood on learning visually presented GLOCAL strings (Tanaka et al., 2008). In the same experiment, test the effect of mood on the visual perceptual task, as this was used in the present study. This could give better insights about the effect of mood on processing through the visual modality, and could help in investigating whether the effect of mood is more robustly present on deeper cognitive processing, compared to superficial general visual focus.
d) In child populations, test how different types of mood affect the learning of an artificial grammar (with adjacent and/or non-adjacent rules). The recommended type of mood manipulation would be writing or thinking about a personal happy memory (film clips might not be ideal for children from an ethical perspective). This research could give useful insights about the effect of mood on children's cognition; are children affected in the same way as adults, therefore learning is also impeded in child populations in a bad mood? Or is it the case that children, due to their superior cognitive and language acquisition capacities, "overpower" the effects of mood and manage to perform equally well, regardless of their mood condition?

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