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The Linguistic Adjustments of the ACT-R Model to the Acquisition of the Simple Past Tense in the Arab Learners of English Context

Anwar Mourssi
Faculty of Arts, Creative Industries and Education,
University of the West of England, Bristol, UK

Abstract
The Adaptive Control of Thought-Rational ACT-R model (Taatgen and Anderson, 2002) is one of the most recent computational models of the acquisition of simple past morphology. This empirical study focuses on the ACT-R model which is proposed in order to explain and predict language acquisition behaviour which may be relevant to the SLA of the simple past and the grammatical construction. The study was conducted on 74 Arab Learners of English (ALEs) which lasted four months. Quantitative and qualitative analysis show that the language behaviour of most of the second language learners can be explained drawing on a recent computational model of the acquisition of simple past morphology, namely the ACT-R model. Linguistic adjustments have been made by the researcher to the ACT-R model, which suggested two more strategies are added to the four strategies proposed by Taatgen and Anderson (2002) and updated by Taatgen and Dijkstra (2005). These two added strategies, namely, the L1 Transfer Strategy and the Overgeneralization of Alternative Category Strategy could capture all forms produced by the ALEs in the acquisition of the simple past tense in the three chronological writing, which the ACT-R model could not capture. The findings of the study reveal that the majority of the learners seemed to follow the six strategies proposed in the adjusted ACT-R model which can best accounted for in the acquisition of the simple past tense in the context of the ALEs.

Keywords: ACT-R model, U-shaped learning model, Crosslinguistic influence, overgeneralization, simple past

1. Introduction

Moursi (2012a, 2012c, 2013) indicates that the acquisition of the simple past is one of the problems Arab Learners of English (ALEs) face in L2 learning English Language. He pointed out that there is a number of models address the acquisition of the simple past tense: some of these models are; Interlanguage model termed by Selinker (1969), the Words and Rules model designed by Pinker (1999), the U-shaped Learning model, and the ACT-R model. This study examines the ACT-R model, followed by investigating its relevance to the acquisition of the simple past tense in the ALEs' context. This paper is divided into five main sections which are introduction, the literature review, the methods used in the current study, the analysis and the discussion, and finally, the conclusion. The following section presents the literature review.

2. Literature Review

First, evaluating the previous models followed by presenting the ACT-R model

2.1 Evaluating the previous models

Moursi (2013) mentions that some linguists assert that over a longer time-scale, a U-shaped curve does exist, at least for a subset of children, (O'Reilly & Hoeffner, 2003, p.2). However, Hoeffner (1997) argues that there is no empirical indication that all language learners exhibit the U-shaped developmental curve. On the contrary, Taatgen & Anderson (2002) claim that there is a host of empirical studies showing the relationship between learning the simple past tense and the U-shaped learning model, (Moursi, 2013).

It was pointed out that another model was presented by Kirby (2001) based on the main idea of the U-shaped learning model, (Moursi, 2013, P.110) and that model was termed as the Iterative learning model (ILM) (p.111). Kirby defines the ILM as a computational implemented model of the transmission of linguistic behaviour. He adds that in ILM, there is no biological evolution, natural selection, nor any measurement of the success of the learners at communicating (except for results-gathering purposes). Nevertheless, counter to intuition, a significant evolution of linguistic behaviour is observed (p.102). Taatgen & Anderson (2002) added that a number of researchers have identified additional aspects related to the U-shape (p.126). As cited by Taatgen & Anderson (2002), a series of empirical studies (Marcus (1996), Marcus et al. (1992), Marchman & Bates (1994)) have suggested a non-linear relationship between the size of the vocabulary and the number of inflected irregular verbs in the simple past tense (p.126). In the following is describing the ACT-R model.

2.2 The Adaptive Control of Thought-Rational (ACT-R) Model

It is worth mentioning that the ACT-R model is a computational model, however, the four strategies proposed by the designers of the model were used to test the data of the study, after some adjustments made to the ACT-R model. Taatgen & Anderson were uncertain what causes the U-shape in the learning of the irregular simple past forms and developed two accounts for that: the dual-representation and single-representations explanations (Taatgen & Anderson, 2002, p.124). The first account focuses on *a dual-representation* of knowledge and posits that in the first instance the formation of the simple past tense is based on memorized verbs (irregular forms). This means that in the first stage, producing the simple past is only successful because the forms have been memorized. If the form of the simple past has not been memorized, it cannot be produced. This case changes in the second stage, when the regular rule is learned: the regular rule can produce the simple past form for any verb, although the forms produced can be non-target-like forms. In these non-target-like forms overgeneralization slowly disappears – that is

what occurred in two recent studies were carried out by Moursi (2012b, 2012d - because more target-like forms are learned. An example: *break – broke – broken* is shown in more detail below.

Stage one: students produce *broke*. Stage two: students produce *broke* if the form is memorized. Students produce **breaked* if the simple past form has not yet been memorized, and then they apply the *–ed* rule. Stage three: students produce *broke* because their memory is strong enough to block the regular rule which produced **breaked* in the second stage.

Memorization is similar to what Pinker (1999) would refer to as "Rote". The simple past tense can also be formed by adding *–ed* to the base form to produce the regular simple past forms and Pinker referred to this as "Rule". Taatgen & Anderson (2002) elaborated on this and explained that in the second stage of the U-shaped learning model, the blocking mechanism would dictate (in the mind) that the regular rule should apply unless an exception can be retrieved from memory. When the process of retrieval fails to recollect an irregular past tense, the U-shape occurs (p.124). With regard to the second account, learning the simple past is regarded as *a single-representation* which is usually present in the neural network. According to Taatgen & Anderson (2002), U-shaped learning is mainly initiated by changes in the vocabulary size which means, as the vocabulary grows, the need for regularization increases. Therefore during the learning process, the network shifts weight to support regularization and it takes some time to properly integrate this with the other exceptions causing the U-shape. Taatgen & Anderson also pointed out that the growth of vocabulary is related to the distinction between the learner's input (which represents the raw input from the environment) and the learner's uptake (which represents what the learner actually processes) (p.124). They explained that one of the problems related to the single-representation model is that children do not receive feedback on the syntactic correctness of the language they produce, but most network models need the correct answer to adjust their weights (in the classroom context, students receive a variety of types of feedback on their performance and this may help ALEs, for example, to develop the target-like usage of the simple past, drawing in part on the strategies produced in Taatgen & Anderson's ACT-R model). In the following section, the four proposed strategies in the acquisition of the simple past tense in the original copy of the ACT-R model are presented.

2.2.1 The ACT-R model and the proposed strategies used in the acquisition of the simple past

According to Taatgen and Anderson (2002), the main aim of the ACT-R model, which is a computational model set up to mimic first language acquisition of the simple past tense, is to produce the past tense with the use of three strategies at the starting point: the Retrieval Strategy, the Analogy Strategy, and the Zero Strategy. The model later learns the fourth strategy which is the Regular Rule Strategy (p.127). *The Retrieval Strategy* aims to produce a past tense by recalling an example of inflecting the word from the memory. Taatgen & Anderson (2002) explain that the successfulness of this strategy depends on the availability of examples. The second strategy, *the Analogy Strategy*, recalls an arbitrary example of a past tense from the memory and tries to use this as a basis for analogy. They posit that the Analogy Strategy will only succeed if it is able to find a pattern in the example which is applicable to the current word. The third strategy, *the Zero Strategy*, is also called the *do-nothing strategy*. It always succeeds, because it does not attempt any inflection at all. Taatgen & Anderson mentioned that associated with each strategy is the expected outcome of that strategy and the estimate for expected outcome is continuously updated on the basis of experience of how much effort it takes to use a

strategy. In other words, the strategy with the highest expected outcome has the highest probability of being tried first, and if it fails, other strategies can be attempted. The fourth strategy, *the Regular Rule Strategy*, is learned on the basis of the Analogy Strategy, but it takes time to surface. That is because new rules can only be learned when the parent rules have sufficient experience, and because the new rules start out with a relatively low expected outcome and first have to prove themselves.

It is proposed that the dynamics of the expected outcomes of the different strategies, the introduction of the regular strategy, and the increased availability of examples of past tenses in memory, can explain U-shaped learning. The assumption of the ACT-R model is that it both perceives target-like forms of past tenses in the environment, and produces them itself. The model does not receive any feedback on its own production.

2.2.2 The ACT-R as a model of learning the simple past tense

Taatgen & Anderson (2002) mention that the ACT-R model initially has to choose between numbers of ways to produce a past tense given the stem of verb. They mention that, first, the model attempts to retrieve the past tense from declarative memory (Retrieve Strategy), then it attempts to generate a new past tense by analogy which retrieves an arbitrary tense from memory and uses it as a template to find a past tense for the current word (Analogy Strategy) (p.133). It is worth mentioning that Lebiere, Wallach, & Taatgen (1998) and Salvucci & Anderson (1998) comment that the Analogy Strategy is probably one of the dominant strategies for problem solving and discovery. Finally, the model uses just the stem as a past tense, basically doing nothing at all (Zero strategy or Zero Rule). The interesting issue here is that the authors themselves evaluate the strategies proposed in the ACT-R model. They mention that none of the proposed strategies are very good initially: the Analogy Strategy involves more than one reasoning step and it is only successful if the retrieved example is suitable; the Retrieval Strategy needs examples before it can be successful, and the Zero Strategy always succeeds, but it rarely produces target-like past tenses (there are some instances, however, where the base form and the simple past are identical, like put). Finally, there is no production rule for the Regular Rule Strategy, because the ACT-R model will learn it as a specialization of the Analogy Strategy (Taatgen & Anderson, 2002, p.134).

Evaluating the Analogy Strategy, Taatgen & Anderson (2002) mention that the Analogy Strategy produces two types of past tense: past tenses identical to the present tense (mimicking the Zero Rule Strategy), and past tenses by adding –ed to the stem. They suggest that the former-present tense will occur much more than the latter –ed in the initial stages of running the model (p.135).

2.2.3 How the model works

The model's strategies will produce different behaviour at different stages in the learning: initial behaviour, behaviour after the model has seen some examples, behaviour after the model has learned the Regular Rule, and finally behaviour after the model has mastered the task.

2.2.3.1 Stage One: Initial behaviour

The model does not know any single example of inflecting words initially, so the Retrieval Strategy and the Analogy Strategy will always fail. The only strategy which is viable is the Zero Strategy, which will produce the stem verbs as past tense.

2.2.3.2 Stage Two: Behaviour after the model has learned some examples

At this stage, the Retrieval Strategy may or may not be successful. If the target-like example is present in the memory and it is sufficiently active, it will be retrieved, producing the target-like past tense. At this stage, the Analogy Strategy is now also a viable strategy. If analogy retrieves an example that does not sufficiently match the target verb, it will fail and will produce the stem as past tenses. It might also produce an irregular verb in which the stem is identical to the past tense e.g. hit-hit. It is also mentioned that, at this stage, when the analogy retrieves a regular example work-worked, it can use this as a template to produce *catched*. Taatgen & Anderson (2002) comment that these occasional regularizations build up eventually so that the model learns the regular rule (p.137).

2.2.3.3 Stage Three: Behaviour after the model has learned the regular rule

As mentioned above, the occasional use of the Analogy Strategy will lead to learning the Regular Rule. At this stage, still, the Retrieval Strategy will remain the dominant strategy. However, because of the huge amount of examples of regular endings, the model will produce *–ed* with irregular verbs **gived*. If the Retrieval Strategy fails to find a past tense, the Regular Rule Strategy is now the backup strategy. The Analogy and Zero strategies will at this stage be used very rarely, because they now have to compete with the Regular Rule Strategy, and with the successful Retrieval Strategy.

2.2.3.4 Stage Four. Behaviour after the model has mastered the task

Taatgen & Anderson (2002) mention that there is no clear moment at which one may judge that the model has mastered the task, but it is the moment when all irregular past tense forms are represented as chunks in declarative memory. At that stage also, regular past tense forms with high and moderate frequencies will be memorized separately as irregular verbs. The Regular Rule Strategy will now only be used for low-frequency regulars and new words, and the Analogy and Zero Strategies will almost never be used any more (p.138).

To sum up, during stage one the main strategies are Retrieval and Do-Nothing. If the Retrieval Strategy succeeds, the model will generally produce target-like irregular verbs, while Do-Nothing produces undetectable errors that are not counted. After the Regular Rule is learned, the transition to stage two begins. An important aspect of the ACT-R model is that the Regular Rule will not dominate the Retrieval Strategy (irregular verbs) although, whenever retrieval fails to find an example, the Regular Rule is applied. This produces the over-regularization errors in irregular verbs. In the following section, methods used in the current study will be presented.

3. Methods

This section discusses the subjects of the study, the research question and the methods used in the analysis of the written texts.

3.1 The subjects of the study

Based on the results of a placement test, two classes were selected from a total of 12 enrolled in grade 12. The target location was in one of the Omani government secondary schools (High School). Each group consisted of 37 Arab Learners of English (ALEs), with ages ranging between 16 and 18, pre-intermediate to intermediate level in English. The subjects were all Arabic speakers and had been learning English as a foreign language for eight years attending four to five sessions per week on average.

3.2 The research question

The current study seeks to answer the following question:
How relevant is the Adaptive Control of Thought-Rational ACT-R model to the acquisition of the simple past tense in the ALEs' context? This is to provide empirical evidence in relation to the acquisition of the simple past tense forms to test hypotheses emerging from the ACT-R model and thus contribute to the advancement of theory on Second Language Acquisition.

3.3 Methods assigned to the research question

For the research question presented above, and to investigate how ACT-R model as a language acquisition model best accounts for the acquisition of the simple past tense, quantitative analysis were followed for all the simple past tense forms produced by the samples in 222 written texts which had been collected chronologically. The ACT-R model was tested to measure how it is relevant with regards to capturing the simple past forms produced by ALEs in the classroom context. In the section below, the relevance of the ACT-R model to the acquisition of the simple past in the ALEs' context will be discussed.

4. The Analysis and the discussion

4.1 The relevance of the ACT-R model to the acquisition of the simple past tense in the ALEs' context

The ACT-R is a computational model, applied by Taatgen & Anderson (2002) to capture behaviour in first language acquisition of the simple past tense. The current study tries to apply the strategies proposed in the ACT-R model to capture behaviour in the second language acquisition of the simple past tense in the ALEs' context in the classroom settings.
Tables 1, 2, and 3 below show the ways in which the four strategies described in the ACT-R model could capture the simple past forms produced in the three chronological written texts collected from each sample in the current study. The first piece of writing (B) was collected after two weeks; the second piece of writing (M) was collected after two months; while the third piece (F) was collected after four months at the end of the experiment.
Tables 1, 2 and 3 below also show how the strategies of the ACT-R model capture the forms of the past tense produced by the ALEs in the three chronological writings. The past tense forms will be distributed as the sequence of the ACT-R model, the Retrieval Strategy, then the Analogy Strategy, after that the Zero Strategy, and finally the Regular Rule Strategy. The tables also show the failure of the strategies during the learning process and the amount of stem and present verbs used instead of the past tense, as mentioned by Taatgen & Anderson (2002) evaluating the performance of the ACT-R model. The section below analyses the relevance of the ACT-R model to writing B.

4.1.1 The relevance of the ACT-R to Writing B

Table 1 below shows the relevance of the ACT-R model to ALEs' writing B. The table presents the four strategies proposed in the ACT-R model: the Retrieval Strategy, the Analogy Strategy, the Zero Strategy, and the Regular Rule Strategy. The table also shows the proportion of the simple past forms captured by each strategy in both groups.
As shown in Table 1 below, the irregular simple past forms captured by the Retrieval Strategy from ALEs writing B is 304 (32.72%) forms. The Analogy Strategy captures 9 (0.97%) forms produced by ALEs in writing B. The third strategy in the ACT-R model, the Zero Strategy, captures 395 (42.52%) forms from writing B. The higher number captured by the Zero Strategy shows how the ALEs start acquiring the simple past tense by producing the root or the simple present instead of the simple past tense forms. The Regular Rule Strategy which is learnt at the last stage captures 221 (23.79%) forms from the simple past tense forms.

Table 1 reveals the results of implementing the ACT-R model and how it is relevant to the ALEs writing B. The model was able to capture 929 out of 1003 forms produced by the ALEs in writing B; however, 74 simple past forms have not been not captured. The model could not capture them due to the fact that they are not matched with any of the four strategies proposed in the ACT-R model. The forms will be captured by the ACT-R model after the adjustment on the model has been made by the researcher at the end of this section.

Table 1: *The relevance of the ACT-R to Writing B*

The Retrieval Strategy	304 (32.72%)
The Analogy Strategy	9 (0.97%)
The Zero Strategy	395 (42.52%)
The Regular Rule Strategy	221 (23.79%)
Total captured forms	929
Left uncaptured forms	74

4.1.2 The relevance of the ACT-R to Writing M

Table 2 below shows the implementation of the ACT-R model on ALEs' writing M. The table shows the proportion of the simple past forms captured by each strategy in both groups. As shown in the table, the Retrieval Strategy captures 345 (37.34%) irregular simple past forms produced by the ALEs in writing M. The Analogy Strategy captures 19 (2.06%) forms from the total of simple past forms produced by the subjects in writing M. The third strategy in the ACT-R model is the Zero Strategy which captures 333 (36.04%) forms. This strategy shows how most of the ALEs still use the root and the simple present forms instead of the simple past tense forms. The table shows that the Regular Rule Strategy captures 227 (24.57%) forms from the total captured simple past forms.

Table 2 reveals the results of implementing the ACT-R model on writing M and how it is relevant to the acquisition of the simple past in stage M. The model was able to capture 924 out of 946 forms produced by the ALEs in writing M, however, 22 simple past forms have still not been captured. These forms will be captured by the ACT-R model after the adjustment applied to the model at the end of this section.

Table 2: *The relevance of the ACT-R to Writing M*

The Retrieval Strategy	345 (37.34%)
The Analogy Strategy	19 (2.06%)
The Zero Strategy	333 (36.04%)
The Regular Rule Strategy	227 (24.57%)
Total captured forms	924
Left uncaptured forms	22

4.1.3 The relevance of the ACT-R to Writing F

Table 3 below shows the implementation of the ACT-R model on ALEs' writing F. The table shows the proportion of the simple past forms captured by each strategy. The table illustrates that, the Retrieval Strategy captures 492 (51.46%) irregular simple past forms produced by the

ALEs in writing F. The Analogy Strategy captures 34 (3.56%) forms from produced by ALEs in writing F. It can be noticed how the Analogy Strategy is reduced due to the conflict between the Retrieval Strategy and the Regular Rule Strategy. The third strategy in the ACT-R model is the Zero Strategy which captures 81 (8.47%) forms from writing M. This strategy shows how much progress occurred in the acquisition of the simple past tense forms in both groups, it can be noticed however, that the subjects achieved more progress in writing F more than writing M. The proportion of the Zero Strategy reduced sharply from 333 in writing M to 81 in writing F. The Regular Rule Strategy which is learnt at the last stage captures 349 (36.51%) forms. The total forms captured by the Regular Rule Strategy are 349 simple past tense forms compared with 227 forms in writing M. The increase of the forms captured by the Retrieval Strategy and the Regular Rule Strategy, and the decrease of the forms captured by the Analogy Strategy and the Zero Strategy, reveal that the development occurs in the acquisition of the simple past tense in both groups during the experiment.

Table 3 below shows the results of implementing the ACT-R model on writing F and of the ACT-R model for the acquisition of the simple past tense in the ALEs' context. The model could capture 956 out of 973 forms produced by the ALEs in writing F; however, 17 simple past forms have not been captured ; this will be captured by the ACT-R model after the adjustment made by the researcher on the model at the end of this section.

Table 3: *The relevance of the ACT-R to Writing F*

The Retrieval Strategy	492 (51.46%)
The Analogy Strategy	34 (3.56%)
The Zero Strategy	81 (8.47%)
The Regular Rule Strategy	349 (36.51%)
Total captured forms	956
Left uncaptured forms	17

4.2 Evaluation of the ACT-R model

The analysis of the simple past forms produced by the ALEs in the three chronological pieces of writing, appears to indicate that the four strategies proposed by Taatgen and Anderson (2002) capture the majority of the variety forms produced by the ALEs in the experiment. It seems, however, that there are some past tense forms which are not captured by the four strategies proposed in the ACT-R model, e.g. how can **are went, *was came, *was gave, *to went, *to visited,* and **has went* be captured by the ACT-R model?

It might be argued that two proposed explanations for the simple past forms which are not captured by the ACT-R model are as follows: firstly, it may be L1 transfer where learners try to apply some rules from L1 on their performance in L2; secondly, it may be due to learners' lack of awareness as well as lack of knowledge: when they learnt the simple past tense, the learners tried to overgeneralize other forms instead of the simple past tense e.g. have or has + simple past, thinking that it might be the correct simple past form. These forms could not be captured by the ACT-R model. The above interpretations led the researcher to adjust the ACT-R model in order to capture all forms produced by the ALEs as foreign language learners in the classroom context.

In my opinion it might be reasonable to propose two new strategies in addition to the four strategies proposed in the existing ACT-R model in order to capture the simple past tense forms produced in the context of ALEs. The two additional strategies proposed are: the L1 Transfer Strategy and the Overgeneralization of Alternative L2 Category Strategy.

4.3 Proposed Adjustments of the ACT-R model

It might be the case that some forms were not captured by the ACT-R model because of differences between L1 and L2. The proposed adjustment is a reply to a study by Taatgen and Dijkstra (2005) in which it was concluded that the only error type not addressed by the ACT-R model was the so-called blends, like *sing-*sanged*, (the forms could not be captured by the ACT-R model as they are not related to the regular rule). Taatgen and Dijkstra (2005) concluded that any other error can be explained by the application of the Regular Rule Strategy. The researcher can claim that this may be the case for the L1 acquisition but is not the case for the L2. In the section below, I will present the adjustment to the ACT-R model in an attempt to capture all simple past tense forms produced by ALEs in the classroom context.

4.3.1 L1 Transfer Strategy

One of the strategies which this study suggests should be added to the model is the L1 Transfer Strategy. One explanation of this proposed strategy is the particular forms produced by ALEs due to the differences between L1 and L2. This strategy seems to suggest two types: the first type is using the *verb to be + stem, agent, simple past, past participle or gerund*. The second type is using *to + stem, or simple past*. The first type is illustrated below.

Type one

The tables below show the occurrence of the sub-types of the L1 Transfer Strategy in both groups. Table 4 shows applying the L1 Transfer Strategy to the three chronological writings (Type One).

Table 4: *Using verb to be + stem, simple past, past participle, or gerund*

Stage	Proportion used forms
Writing B	41 (75.93%)
Writing M	7 (12.96%)
Writing F	6 (11.11%)
Total	54

Type two

Table 5 shows applying the L1 Transfer Strategy to the three chronological writings (Type Two), where ALEs use *to + stem or simple past*

Table 5: *Using to + stem, simple past*

Stage	Proportion used forms
Writing B	10 (66.67%)
Writing M	3 (20.00%)
Writing F	2 (13.33%)
Total	15

4.3.2 Overgeneralization of Alternative L2 Category Strategy

The second proposed strategy may be the Overgeneralization of Alternative L2 Category Strategy. In this strategy, the learners use alternative forms of the simple past which are: the present perfect forms 7; the present continuous 4; the past continuous 9; the gerund 19; the past

participle 2; and finally nouns 3. The learners think that the alternative forms can give the same meaning as the simple past in the English grammar. It is worth mentioning that learners in both groups used more alternative forms in writing B which decreased dramatically in writing M and F. The prevalence of the Overgeneralization of Alternative L2 Category Strategy in the first writing - stage B - seems to suggest that learners' lack of knowledge or the fluctuation in producing the target-like simple past tense forms operate at the beginning of the experiment. It is also worth mentioning that, after the ALEs spent more time learning the simple past tense forms, the Overgeneralization of Alternative L2 Category Strategy decreased as is shown clearly in Table .6 below. Most of these forms rarely appear at stages M and F.

Table 6: *Using have or has + simple past, past participle, or any other L2 alternative form*

Stage	Proportion used forms
Writing B	23 (52.27%)
Writing M	12(27.27%)
Writing F	9 (20.45%)
Total	44

In updating the ACT-R model, Taatgen and Dijkstra (2005) presented an extension of the ACT-R model designed by Taatgen and Anderson (2002). They only added change is that, when the model produced **sanged* instead of *sang*, it meant that it considered the verb "*sang*" as a stem verb. It is worth mentioning that the four strategies proposed in the ACT-R model were found in the production of the simple past tense forms in the classroom context with ALEs. The adjustment made by the researcher could capture all simple past forms produced by all the subjects in the experiment. It is also worth mentioning that the two strategies added by the researcher to the ACT-R model are the same different interlanguage stages found in the context of the ALEs in the acquisition of the simple past tense forms from the interlanguage stages found in other studies. The two additional strategies added to the ACT-R model represent the specific characteristics of the context of the ALEs in the acquisition of the simple past tense, Mourssi (2012a, 2012c).

To sum up, most of the past tense forms produced by ALEs appear to indicate that the ACT-R model can be the most relevant model to the acquisition of the simple past tense in the context of ALEs, and that the forms which were not captured by the ACT-R model, could be captured by the adjustment made to the strategies proposed for the ACT-R model by adding two more strategies, namely, the L1 Transfer Strategy and the Overgeneralization of Alternative L2 Category Strategy.

Limitations of the study

The current study set out to investigate the relevance of the ACT-R model in second language acquisition of the simple past. This study analyses only four months in the students' language development and cannot be said to be a comprehensive or longitudinal survey. It may, however, provide insights into the nature of L2 acquisition particularly in taught (rather than naturalistic) contexts.

5. Conclusion

The findings reveal that the ACT-R model offers insights into the process of Second Language Acquisition (SLA) and is therefore integrated in classifying how ALEs learn the simple past tense forms and possibly other grammatical features as well.

The findings of the study reveal that the majority of the learners seemed to follow the six strategies proposed in the adjusted ACT-R model which can best accounted for in the acquisition of the simple past tense in the context of the ALEs. The learners in both groups started producing target-like forms from the beginning of the experiment, thus drawing on what the ACT-R model refers to as the Retrieval Strategy. This was followed by producing non-target-like forms using the Zero Strategy and the Analogy Strategy. After spending more time learning the simple past tense forms, the learners used the Regular Rule Strategy and at the end of the experiment, most L2 learners used the Retrieval Strategy and the Regular Rule Strategy, while the use of Analogy Strategy and the Zero Strategy decreased sharply. The adjusted ACT-R model could capture all the simple past tense forms produced by all the learners in the experiment

Another conclusion from the discussion here is that the more Arabic L1 English language learners receive comprehensible input, the greater their proficiency. It is a question of time spent in interaction between the teacher and the students. When it is decided to apply the ACT-R model on L2 writing, overgeneralization of irregular forms to the regular ones or vice versa (such as **brang, *gived, *catched, *camed, *broked* and **telled*), Language Transfer (the cross-linguistic influence of L1 in learning L2), and overgeneralization of alternative categories on the simple past tense forms were taken into consideration. Therefore, it takes ALEs time to absorb the morphological rules of the simple past tense forms in English in their internalized grammatical system.

Finally, based on the data derived from the implementation of the ACT-R model on the three chronological writings, the researcher claims that the ACT-R model can be the most relevant model to the acquisition of the simple past tense in L2.

About the Author:

Anwar Moursi received his M.A in TESL/TEFL from Birmingham University/UK in 2006, and his PhD in Applied Linguistics from University of the West of England, Bristol/UK in 2012. His major field of study is Second Language Acquisition and he is interested in error analysis, FFI and ELT methods. Currently he is assistant professor at Higher College of Technology, Muscat, Oman.

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