

# Visualizing Cognitive Load Dynamics: A Theory on Interplay of Cognitive Factors in Second Language Acquisition

Gross, T.<sup>1\*</sup>, Wagner, M.<sup>2</sup>. and Zerrouki, Y.<sup>3</sup>

<sup>1</sup>SRH University Heidelberg, Germany

<sup>2</sup>Ministry of Education, RLP, Germany

<sup>3</sup>Institut de Savoir, Morocco

\*Corresponding author: [info@tobeygross.de](mailto:info@tobeygross.de)

Received: 18 Mar., 2023

Revised: 31 May, 2023

Accepted: 10 Jun., 2023

## ABSTRACT

This research paper explores the impact of cognitive load on second language acquisition, focusing on the differences between traditional grammar-focused teaching methods and a Cognitive Load Reduction Curriculum (CLRC) approach. In our study, we have chosen to include logical equations as a means to clearly demonstrate the complex interplay between various cognitive factors in SLA. The primary goal of this inclusion is to offer a visual representation of the different relationships between the attributes and factors involved in language acquisition, with a particular focus on cognitive load. By providing equations and their according graphs, we aim to make our assumptions transparent and comprehensible, allowing readers to better grasp our reasoning behind the relationships we propose. Those are based upon findings from existing research and equally our experiences in numerous controlled settings, ultimately leading to according derivations. Our findings suggest that CLRC is more effective in managing cognitive load, resulting in increased student confidence and improved language learning outcomes. Furthermore, we discuss the practical implications of our findings for educational facilities and offer some suggestions for future research.

**Keywords:** Cognitive Load, SLA, Educational Science, Educational Psychology, CLRC

The field of second language acquisition has long been dominated by traditional, grammar-focused approaches to teaching. As though traditional language teaching methodology is not necessarily outdated or without any success, it often creates a high cognitive load for learners, which can result in a slower learning process and increased potential for errors. Drawing on our own promising experiences with German and Arabian speakers learning English as a second language, we propose a novel approach that reverses the order of grammar instruction and conversation practice, aiming to significantly accelerate language acquisition and eliminate the error potential on account of high cognitive load.

**How to cite this article:** Gross, T., Wagner, M. and Zerrouki, Y. (2023). Visualizing Cognitive Load Dynamics: A Theory on Interplay of Cognitive Factors in Second Language Acquisition. *IJASE*, 11(01): 65-78.

**Source of Support:** None; **Conflict of Interest:** None

This unique investigation puts conversation at the forefront of the learning process, allowing students to become familiar with syntax and morphological structures and language patterns before delving into the underlying grammar rules. By engaging in conversation from the earliest stages on, learners can circumvent the error-prone process of internalizing complex rule sets and their correct application. Instead, they confirm their intrinsic knowledge with grammar rules after they have already been correctly retrieved, applied, and proficiently mastered. It is important to consider that there have been conversation-based approaches in SLA, quite successfully so, however this investigation aims to apply self-developed approaches but also make assumptions on the cognitive processes and their relationships among one another in order to determine weaknesses in traditional methodology, benefits in immersive and conversation-driven environments and staking out the certain areas in performance, where they substantially differ. The following is thus to be regarded as an experience-based report.

Our method, which we term the Cognitive Load Reduction Curriculum (CLRC), is grounded in the belief that a more natural language acquisition process will result in a significantly reduced failure rate. Although we have not yet gathered measurable quantitative data to support the effectiveness of the CLRC, our experiences with language learners suggest that this approach has great potential for improving the overall language learning process. We believe that further research and investigation into the CLRC will contribute to a better understanding of the cognitive processes involved in SLA and mainly the connection between cognitive load and error-proneness in learning and applying linguistic structures and ultimately lead to more effective teaching methods.

Central to the CLRC - and different from existent research - is the concept of the “failure space,” later labelled  $\Delta CL(t)$ , which we propose arises from the cognitive load imposed on learners by traditional grammar-focused teaching methods. According to our experience in various controlled environments, when learners are taught grammar rules first and then asked to apply them in conversation, they must engage in a series of complex cognitive processes. These processes include perception of language input, identifying the input, retrieving matching grammar information, forming associations, and ultimately processing language output. The retrieval and matching process, in particular, creates opportunities for misunderstanding, misconceptions, and other errors, leading to the formation of the failure space.

In contrast, the CLRC aims to minimize the failure space by engaging learners in conversation from the beginning, without initially burdening them with explicit grammar rules. This approach allows learners to focus on producing language output based on the structures and patterns they naturally acquire through conversation. As learners become more proficient, they can gradually be introduced to the underlying grammar rules, which then serve to confirm and solidify their existing knowledge and forming more abstract associations that will later be encoded in their meta-memory.

By effectively circumventing the failure space, the CLRC reduces the cognitive load on learners and allows for a more natural and efficient language acquisition process. This approach is grounded in our belief that language learning can be significantly improved by addressing the cognitive challenges imposed by traditional teaching methods and harnessing the brain’s natural capacity for acquiring language. It is worth noting that the natural language acquisition process of native speakers shares similarities with the CLRC approach. Native speakers learn their first language primarily through engaging in conversation and exposure to authentic language input in their environment. This process naturally works without explicit grammar instruction, as there has not yet been formed any linguistic foundation that could be used as a transmission basis. In other words, you can not teach a language in another language, if the recipient has

none. Children do not only lack the cognitive capacity to process complex grammar rules, but neither do they possess a meta-linguistic understanding of their native language. Instead, they intuitively learn to produce accurate language output based on the language they encounter in their surroundings and thereby gather their foundation solely through input-output mechanisms that receive feedback upon the production of errors. This process of encoding information, according to our belief, can be reproduced at later stages just as well.

We are confident that implementing the CLRC in second language learning contexts can lead to more efficient and natural language acquisition. Building on the principles of CLRC, our approach not only emphasizes the importance of conversation-first instruction but also carefully considers the order and selection of content. Through focusing on conversational abilities, we seek to reduce the cognitive load and thus decrease the potential for failure space to emerge.

Though, it is important to clarify that the CLRC does not advocate for a selective or limited teaching of language content overall; but rather presents a thoughtfully restructured order of topics. In the CLRC, some content typically covered in traditional curricula may be deferred to a more appropriate time, allowing learners to first develop a strong foundation in conversational abilities through enabling them to proactively and intuitively use their already memorized and encoded structures and simply skipping the necessary step in between the former and the output: associating and processing rule-sets.

This approach ensures that learners are not overwhelmed by excessive grammar rules and can more effectively acquire language in a manner that resembles natural language acquisition. The ultimate goal of the CLRC is to provide a more efficient and intuitive pathway for language learning that significantly reduces cognitive load and the associated failure space, ultimately accelerating the learning procedure and increasing confidence.

## LITERATURE REVIEW

In a 1988 study, J. Sweller demonstrates how an excess cognitive load negatively affects learning progression. This is a fundamental finding for our work since it aligns with our findings, as we observed that the traditional grammar-focused approach imposes a higher cognitive load on learners, leading to increased error-proneness and decreased confidence in SLA. The application of cognitive load theory to our research helps to emphasize the potential benefits of the CLRC approach in reducing cognitive load and enhancing the language learning process<sup>[10]</sup>.

Paas' *et al.* (2003) paper is directly related to our research on the impact of cognitive load in second language acquisition<sup>[7]</sup>. It explains how important comprehension and management of cognitive load is, when designing educational materials and teaching methods - based on their Cognitive Load Theory (CLT), which is probably the most crucial and foundational work in terms of this, and our, idea. Our CLRC approach is directly grounded in these principles, as we aim to reduce extraneous cognitive load by focusing on meaningful communication and real-life contexts.

Ellis' (2008) relatively recent book lends credibility to our research and strongly supports the idea that optimizing cognitive load through methods like CLRC can lead to more efficient language learning experiences<sup>[4]</sup>. This is mainly through the important considerations it makes us aware of: cognitive processes are of utter importance when it comes to developing methodologies in teaching an L2.

Baddeley's (1992) seminal work on working memory forms an important foundation in understanding the cognitive process in SLA in terms of how the working memory is used<sup>[2]</sup>. It clearly states, how cognitive load has a major impact on the working memory capacity, resulting in negative outcomes once the cognitive load gets too high for a learner to overcome. The fact, that the CLRC puts an emphasis on the natural conversation leaves learners with a considerably reduced cognitive load and thus has them utilize more capacity in their working memory; thus a decrease in cognitive load is an important factor in enhancing the SLA overall performance.

In the context of the CLRC approach, reducing cognitive load allows learners to allocate more attentional resources to noticing and processing linguistic input, which, according to Schmidt's (1990) "Noticing Hypothesis"<sup>[9]</sup>, is crucial for language acquisition. Awareness, in meta-linguistic terms, is reduced while a learner uses their cognitive capacities to form above mentioned associations, applying rule-sets to input in order to form corresponding output. One of the main beliefs of our research is based on this principle: while a learner has to employ their cognitive capacity for the number and order of processes that traditional approaches require, the intake and processing of the actual input is highly reduced. Thus, a traditional approach must contradict the beneficial features that a natural approach has on the learner's processing abilities.

This belief is strongly supported by Van Patten *et al.* (2007) in their work about on the role of cognitive factors in shaping learner's ability to process and internalize linguistic input<sup>[11]</sup>.

DeKeyser's (2000) study primarily focuses on the critical period hypothesis and the advantage younger learners have in acquiring language skills due to the decreasing cognitive flexibility and ability to assimilate new information over a learner's lifespan<sup>[3]</sup>. While this work does not directly address the cognitive load for older learners in SLA, the findings can be interpreted to suggest that older learners might face more of a challenge given an equally high cognitive load. Consequently, the cognitive load associated with traditional grammar-focused approaches could be even more of a burden for older learners in SLA.

The CLRC further aligns with Long's (1996) ideas of prioritizing authentic communication and focusing on learners' engagement in real-life contexts rather than focusing solely on grammar rules and abstract exercises<sup>[6]</sup>. Thus, internalizing content on the basis of a well-managed cognitive load through methods of conversation-based curricula take away the abstract nature of grammar-based instruction models, which regularly overwhelm learners and consequently form the failure space we suggest in this paper.

Furthermore, given that failure space, Krashen's (1982) focus on a low affective filter also supports the idea that reducing cognitive load can positively impact language acquisition by lowering anxiety and stress levels in learners, which, according to Krashen, is crucial to successful language learning<sup>[5]</sup>.

Lastly, Willis' & Willis' (2007) groundbreaking work on task-based language teaching (TBLT)<sup>[13]</sup>, which was adopted into previous yet unpublished works of this paper's first author, connects to the beliefs behind the CLRC as the TBLT principles put high importance in engaging learners in authentic use of the target language much rather than decontextualized exercise.

## **Theoretical Framework and Visualization Modeling Equations**

In this chapter, we will present theoretical equations that are supposed to visually represent the relationships between cognitive load, time, and the failure space in both the traditional grammar-focused approach and CLRC. These equations serve as a visual representation of the assumptions and observations we have

made in our educational facilities and are not meant to resemble numeric values in the measurement of cognitive load, because that would ultimately result in over-generalization. However, by providing a theoretical quantitative model, we aim to offer a deeper understanding of the differences between the traditional and CLRC approaches, as well as to highlight the potential benefits of actively cutting down cognitive load and thus skipping over the associated failure space.

The traditional grammar-focused approach is represented by the equation:

$$CL_{trad}(t) = \left[ C_1 \cdot e^{(C_2 \cdot t)} \right],$$

where, the cognitive load ( $CL_{trad}$ ) increases exponentially over time ( $t$ ). The constants  $C_1$  and  $C_2$  determine the scaling and steepness of the increase in cognitive load, respectively.

For CLRC, we have chosen to represent the cognitive load ( $CL_{clrc}$ ) using a logistic growth model, as it closely resembles the natural process of language acquisition. The equation to visualize the assumed behavior of cognitive load in CLRC is:

$$CL_{clrc}(t) = \left[ \frac{L}{1 + e^{\frac{-(t-t_0)}{\tau}}} \right]$$

$$\lim_{t \rightarrow \infty} CL_{clrc}(t) = L$$

where,  $t_0$  corresponds to the inflection point of the curve, and  $\tau$  is the time constant that characterizes the time it takes for the curve to reach a certain fraction of the final CL-limitation, represented by  $L$ , a permanent limit of the cognitive load for CLRC as time goes to infinity. This property of the logistic growth model is consistent with our own assumption that, at a certain point in time, the cognitive load in CLRC will not increase any further, whereas, in contrast, the cognitive load continues to increase exponentially over time with trad, imposing an ever-growing base of rule-sets onto learners which are practiced to exhaustion in abstract exercises built upon one another.

To visualize the difference in cognitive load between the traditional and CLRC approaches, we are able to theoretically calculate the failure space as the according growing difference between the aforementioned, represented by the equation:

$$\Delta CL(t) = \left[ C_1 \cdot e^{(C_2 \cdot t)} \right] - \left[ \frac{L}{1 + e^{\frac{-(t-t_0)}{\tau}}} \right]$$

$$\Leftrightarrow \Delta CL(t) = CL_{trad}(t) - CL_{clrc}(t).$$

This equation illustrates how the cognitive load difference between the two approaches evolves over time, with the failure space increasing as the traditional approach continuously imposes a higher cognitive load on learners. In the context of our research, the failure space represents the increased potential for errors and misunderstandings that arise from the higher cognitive load experienced by learners. This increased cognitive burden makes it more difficult for learners to process, understand, and apply the complex grammar rules they are taught, leading to a higher probability of mistakes. By quantifying the failure space through the delta difference in cognitive load, we can visually represent and better understand

the impact of traditional and CLRC teaching methods on the language learning process. This further emphasizes the potential advantages of the CLRC approach in accelerating language acquisition and reducing error-proneness in learning and applying linguistic structures.

The provided equations help us understand the relationships between cognitive load, time, and the failure space in both teaching methods. By comparing the equations visually, we can clearly see the advantages of the CLRC approach in reducing cognitive load and the associated failure space. We believe that these relationships are valid assumptions based on our observations of the language learning process in our educational facilities. Moreover, they emphasize the potential of the CLRC approach to accelerate language acquisition and reduce error-proneness in learning and applying linguistic structures.

Importantly, the growth rate of  $\Delta CL(t)$  is to be understood as growing relatively more, faster, naturally, at any t-value past  $L$  than before  $L$ . This can be calculated and represented as follows:

The first Leibnitz derivative of the cognitive load functions for both the traditional and CLRC approaches represents the growth rates of the cognitive load over time. Below, we calculate how these growth rates change from before  $L$  and after  $L$  for each approach.

For the traditional approach, the growth rate is expressed as:

$$\frac{dCL_{trad}}{dt} = C_1 C_2 e^{C_2 t}$$

This growth rate is always positive and increases exponentially with time, as the base of the exponent, is greater than 1. This means that the cognitive load for the traditional approach keeps increasing at an accelerating pace over time.

For the CLRC, the growth rate is given by:

$$\frac{dCL_{clrc}}{dt} = \left[ \frac{L \cdot e^{-\frac{(t-t_0)}{\tau}}}{\tau \cdot \left(1 + e^{-\frac{(t-t_0)}{\tau}}\right)^2} \right]$$

This growth rate is also positive but has a more complex behavior. At the beginning of the learning process, the growth rate increases until it reaches a peak, and then starts to decrease. As time goes to infinity, the growth rate approaches zero, which means the cognitive load for the CLRC approach reaches a stable value  $L$  and does not increase further. Now we can analyze the change in growth rate of the delta difference  $\Delta CL(t)$  by utilizing the same method as above:

$$\begin{aligned} \frac{d\Delta CL(t)}{dt} &= \frac{dCL_{trad}(t)}{dt} - \frac{dCL_{clrc}(t)}{dt} \\ \Leftrightarrow \frac{d\Delta CL(t)}{dt} &= [C_1 C_2 e^{C_2 t}] - \left[ \frac{L \cdot e^{-\frac{(t-t_0)}{\tau}}}{\tau \cdot \left(1 + e^{-\frac{(t-t_0)}{\tau}}\right)^2} \right] \end{aligned}$$

As time progresses and the CLRC approach reaches the limit  $L$ , the growth rate of the CLRC cognitive load  $\frac{dCL_{clrc}}{dt}$  approaches zero. At this point, the change in growth rate of the delta difference is mainly determined by the growth rate of the traditional approach:

$$\frac{d\Delta CL(t)}{dt} \approx \frac{dCL_{trad}(t)}{dt}$$

Since the growth rate of the traditional approach keeps increasing  $\Delta CL(t)$ , will also grow more as the CLRC cognitive load growth rate reaches and permanently remains zero. This indicates that the failure space between the two approaches continues to widen as time progresses further, which, in terms of our research, highlights the potential benefits of the CLRC approach in management of cognitive load and in reducing error-proneness in the SLA process.

Apart from that, our additional assumption is, that the level of confidence is anti-proportional to the cognitive load. Our observations in conversational instruction supported the opinion, that a significant reduction in cognitive load goes with a noticeable increase in confidence and fluency, which again strongly supports the idea of the failure space - a theoretical void of uncertainty - to overcome. We seek to represent the inverse relationship between cognitive load and confidence with the random variable in the according equation:

$$con_{(t)} = \frac{z}{CL_{(t)}}$$

to indicate the learner's confidence level at a given time of the instruction phase. To analyze the relationship between the confidence level and the delta function of the cognitive load growth rate, let's first write down the confidence level equation for both the traditional and CLRC approaches, considering the inverse relationship:

For the traditional approach:

$$con_{trad}(t) = \frac{z}{CL_{trad}(t)}$$

For the CLRC approach:

$$con_{clrc}(t) = \frac{z}{CL_{clrc}(t)}$$

As we seek to understand the confidence level behavior in relation to the delta function of the CL growth rate, we have to calculate the ratio of confidence levels between the CLRC and traditional approaches:

$$\frac{con_{clrc}(t)}{con_{trad}(t)} = \frac{\frac{z}{CL_{clrc}(t)}}{\frac{z}{CL_{trad}(t)}} = \frac{CL_{trad}(t)}{CL_{clrc}(t)}$$

This ratio is now perfectly equal to the inverse of the delta function of the cognitive load:

$$\frac{CL_{trad}(t)}{CL_{clrc}(t)} = \frac{1}{\Delta CL(t)}$$

As the delta function of the CL growth rate increases over time, the ratio of confidence levels between the CLRC and traditional approaches decreases, meaning that the confidence level of students using the CLRC approach is expected to be higher than those using the traditional approach.

Moreover, as the failure space increases through widening difference in cognitive load between the former and the latter, the confidence levels in the traditional approach are likely to decrease, while those in the CLRC approach are expected to remain relatively stable or even increase. This further highlights the potential advantages of the CLRC approach in terms of fostering confidence in language learners.

As we have now been able to show, it is logically explainable that given the pre-assumptions of relationships between the properties of the aforementioned teaching approaches, it is possible to determine their impacts and effects onto students and to predict their further progression and ultimately their results in the SLA process. Upon those deductions, we believe to make the adverse effects of a (too) high cognitive load over a given timespan more visible, as its increase deteriorates student performance regularly. Making the phenomenon of our original theory - the failure space - more tangible and imaginable through employing above equations, it becomes quite understandable, how cognitive processes in students' encoding and memorizing can be positively altered through employing methodology that is designed to target these shortcomings in traditional grammar-based teaching.

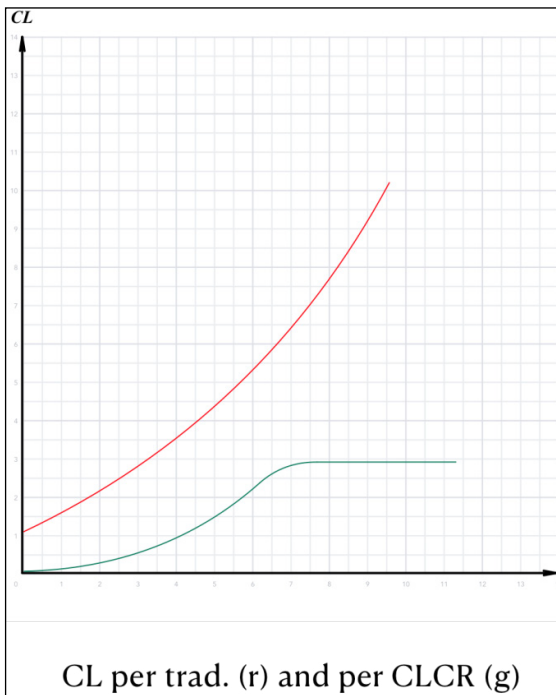


Fig. 1

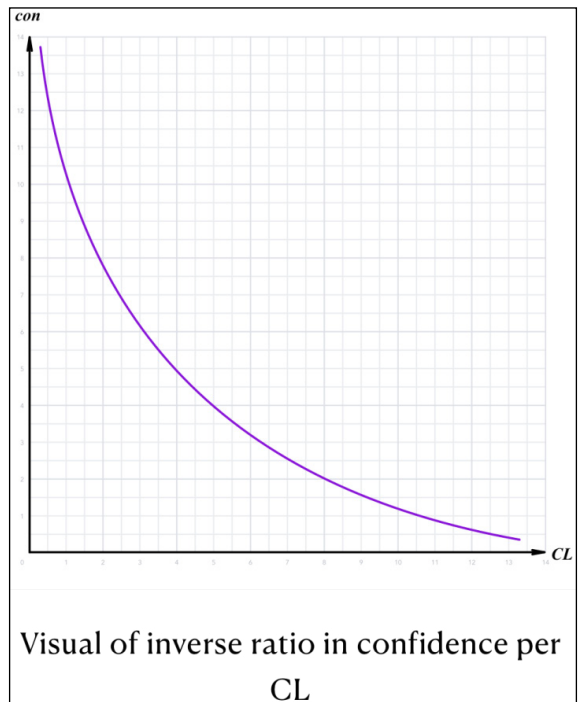


Fig. 2



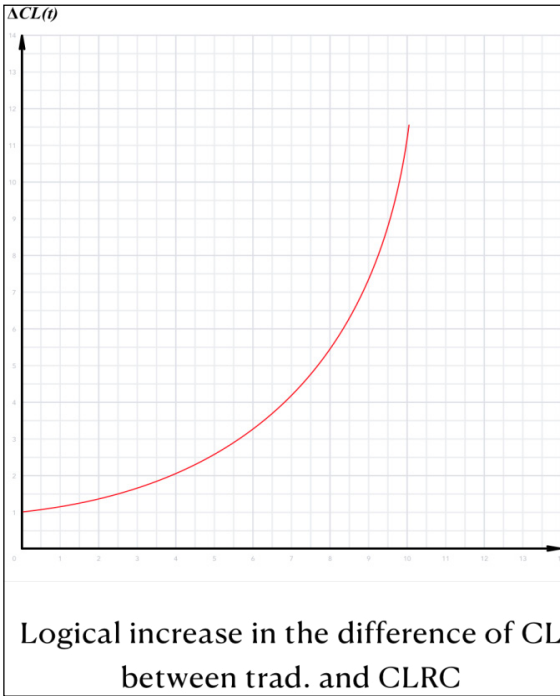


Fig. 3

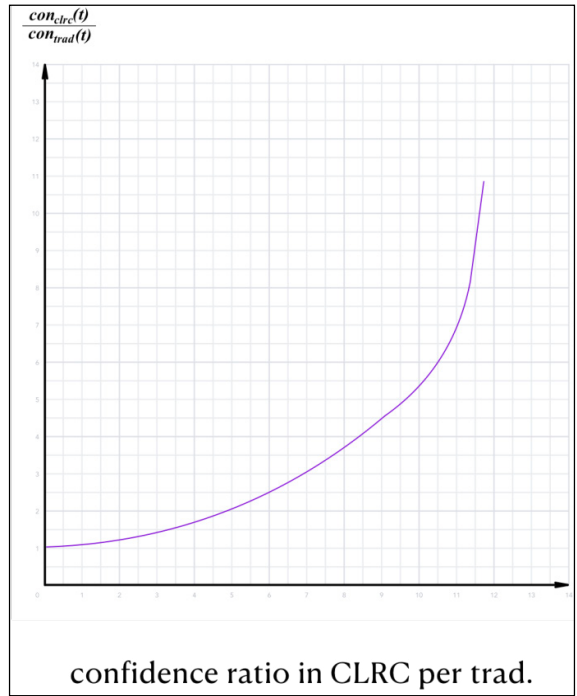


Fig. 4

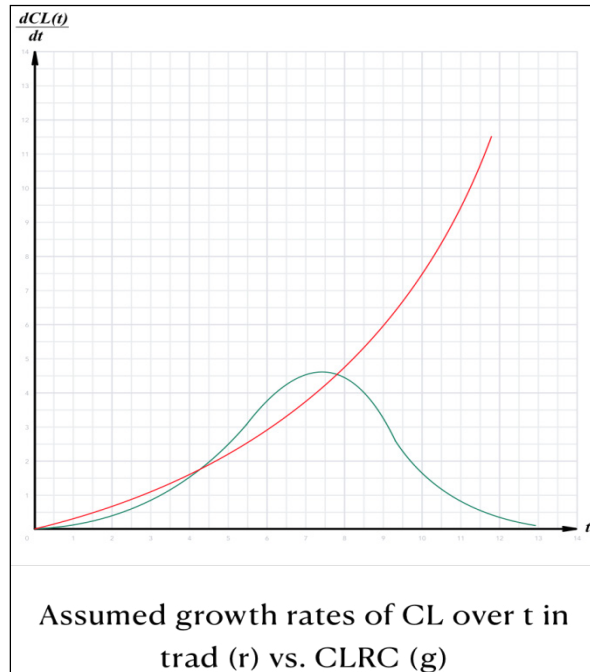


Fig. 5

**Legend:**

$t$  : Time, representing the progression of language learning.

$CL_{trad}(t)$  : Cognitive load in the traditional grammar-focused approach at time  $t$ .

$CL_{clrc}(t)$  : Cognitive load in the Cognitive Load Reduction Curriculum (CLRC) approach at time  $t$ .

$\Delta CL(t)$  : The difference in cognitive load between the traditional approach and the CLRC approach at time  $t$ .

$C_1$  : A constant that scales the cognitive load in the traditional approach.

$C_2$  : A constant determining the steepness of the cognitive load increase in the traditional approach.

$L$  : The permanent limit of cognitive load in the CLRC approach, reached as time goes to infinity.

$t_0$  : The time at which the inflection point (the point where the curve changes concavity) occurs in the CLRC approach.

$\tau$  : The time constant in the CLRC approach, characterizing the time it takes for the curve to reach a certain percentage of the final value ( $L$ ).

$e$  : Euler's number, constant as the base for natural logarithms.

$d$  : The first Leibnitz' derivative, used in order to determine the growth rate of the underlying functions.

$con$  : Confidence level, used in the equation  $con = z/CL$  to describe the anti-proportional relationship between confidence and CL.

$z$  : imaginary constant in the con-CL ratio to show the inverse ratio between the two former variables.

$con_{trad}(t)$  : Theoretical level of confidence after utilization of the *trad.* approach at time  $t$ .

$con_{clrc}(t)$  : Theoretical level of confidence after utilization of the CLRC approach at time  $t$ .

**Bridging from Experience to Theory**

The inception of our numerous assumptions and subsequently the CLRC were not arbitrary; they originated from experiences drawn from direct classroom interactions and one-on-one teaching sessions. Our experiences strongly point towards a recurrent pattern, where learners experience high cognitive loads after having been instructed with grammar-based rule sets and subsequently struggle at their correct retrieval and application in natural conversation settings. It was regularly observed, regardless of learner demographics and type of setting, that traditional grammar-based approaches imposed a high load on learners' cognitive capacities which led to prolonged retrieval time-frames, unnatural conversational situations, subjectively uttered feelings of intimidation due to the high amount of theoretical knowledge and subjectively felt abstract knowledge-sets that were uneasy to bridge into immersive controlled settings. Those first observations opened our minds for the theory, that grammar-based instruction at the forefront might just not be the state of the art instruction model and melted into several experimental phases, where more and more of the mere theory - at the very forefront - was abolished whilst keeping close track of the contrastive progress and the subjective experiential application of knowledge in SLA. It became clearer, that learners would not need the strongly theoretical instruction in order to converse and just be exposed to linguistic frameworks from the instructors, ultimately leading to a timely adoption of the same, their correct retrieval and application, all while unbeknownst, that inherent grammar rules had already been correctly soaked up through mere attention and conversational practice. Existing

research on the language acquisition process of the first language, whichever it might be, aligns with our original theory, that grammar-based approaches are non-essential to language acquisition. Our findings, however, would go further than that; as to propose, that not only would grammar-based instruction at the forefront be obsolete in order to shape linguistic proficiency, but also that it would under perform in contrast to mere conversation-based approaches, due to the processes that learners went through in both, existentially different, learning frameworks. Our further observations were developing their shape through pre-assumptions that mainly dealt with the idea of a high, and exponentially increasing, cognitive load and a very distinct process in the brains of learners, which was all but a coincidence: it could be clearly observed, that retrieval and application of information worked essentially different with learners who were not originally aware of the underlying rule-sets which they were going to apply in their conversation, versus those who had to work through different sequential steps in order to produce the same quality output.

Moreover, the latter showed to be considerably more error-prone, taking longer, subjectively more insecure, and ultimately easier frustrated. Experiences and observations of different research settings merged into extended discussions on the topic among our involved research personnel, first gathering insights in the different teaching and learning situations, comparing performance and experiences in qualitative manner, and eventually discussing previous research in order to find clues on our ideas on the interplay of different cognitive factors that appear to have compounded and interactive impact on the processes we had observed and documented. Constant observation, adjustments and contrastive comparison with aligning research led to an increasingly detailed insight into the cognitive processes involved in language acquisition in one or the other way. It became clear, that the results that had previously been manifested, were indeed no coincidence, due to the broad parameters that had been set: it did indeed neither matter what the first, nor, what the second language was, equally indifferent were the specific properties of learners, such as demographics and first language proficiency, as well as differing classroom size or even one-on-one instruction. Speakers of Standard Arabic with English as their  $L_2$  were observed in Moroccan classrooms, as well as they could be instructed in Germany in case they had come to the country as refugees at different ages. To some though, English was their  $L_3$  since they had already been sufficiently speaking German, some had not. Among German native speaking students who were learning English as their  $L_2$  and their  $L_3$ , Arabic native speaking students in both Morocco and Germany, as well as students who were learning German as their  $L_2$ , observations showed considerable alignment. In a considerable number of cases, it could even be noted, that native Standard Arabic speaking students performed poor in frameworks of their own native language after syntactic instruction in rule-sets and subsequent syntax and morphology tests. A group of subjects who were of particular interest in German classrooms were Ukrainian refugee students who had fled from the violent military altercations with Russia that at the time of this work were taking place in their home country. It could be observed, how deductive language instruction in German did explicitly not yield results anywhere near the ones yielded by mere conversations with peers, where linguistic frameworks were listened to, copied and entrenched through casual use, inductively.

On the other hand, the process of encoding and retrieving similar frameworks through deductive, rule-based instruction with subsequent exercise in syntax and morphology did not only apparently under perform in comparison, it even showed to slow down the process of language acquisition tremendously, compared to the casual, conversational intuitive adoption of the same frameworks. This discovery could be verified through case observations, where the Ukrainian learners became so inconfident, that they chose to circumvent German entirely and instead code-switch to English as a common denominator.

Whenever an approach was based on grammar rule-set instruction and subsequent build-up of abstract exercise-based proficiency, conversational skills fell short of the expected knowledge and proficiency level, whereas those who had obtained their language skills through conversation-first approaches, regardless of when or if at all they had been exposed to rule-sets, vastly outperformed the former. As to understand, where the distinctions were, and to rule out confidential occurrence, as well as to verify our then emerging theory, many of the former students - namely those, who appeared to struggle with grammar-based top-down instructional models the most, were very abruptly switched to conversation-only instruction and specifically asked to listen carefully and try to adopt frameworks they hear, just in order to converse fluently. The results were dramatic: not only were proficiency improvements substantial, but also the reported cognitive load, effort, confidence and all our investigated parameters changed to an extreme extent. Comparable groups, who had subsequently been instructed through conversation curricula from scratch, and which closely resembled the properties of the aforementioned groups, achieved comparable proficiency in a fraction of the time-frame and did not at all report any increase in their subjectively felt cognitive load, as their proficiency grew just with the conversation, naturally and progressively. The observed amount of errors was, as expected, considerably lower. As mentioned, there has not yet been a quantitative exploration, and nor does this paper claim qualitative methodology, since as for now it only serves as a report of our observations and the according theory on interplay of the above mentioned cognitive factors that come into play during the acquisition process of a second language. As an outlook, there will have to be much more research done on qualitative properties of the theory, however, the amount of students, the distinctions in settings and demographics, as well as the observed time frames and methodologies conducted by highly skilled educational personnel, lend a high amount of credibility to the proposed ideas. The equations in the previous chapter, however, do not claim mathematical reliability but represent a visual method to comprehend in which logical manners we believe the different cognitive features influence and alter each other derived from how we perceived and meticulously documented the discussed phenomena.

The supposed interactions between the different parameters were thus all based on a comprehensive alignment of sufficient observation, documented learner utterances, prevailing beliefs in pre-existing research, contrastive trial episodes, expert discussions and formation of coherent derivative methodology with benchmarks.

## **CONCLUSION**

Our long-term experience together with our documentations and case studies have shown us a variety of reasonable arguments for the substantial discussion of problematic features in rule-based grammar instruction. Pre-existing research suggests, that there is a critical cognitive capacity in processing information, a phenomenon at which language acquisition is no exception. Since the process of acquiring a language employs several different areas of the human cognition, it is not surprising, that improper handling of the aforementioned capacities can easily produce a cognitive overload which ultimately results in error, stress and inconfidence. Our numerous observations strongly point into the direction, that in second language acquisition, the approach of teaching linguistic frameworks through grammar-based instruction, imposes a considerable cognitive load onto learners, because as pre-existing research has confirmed, the different sequential phases of encoding, retrieving and applying language information require a number of different brain activities that work as follow-up steps and result in a linguistic output.

The more complex the required output, the more linguistic frameworks have to be scanned, retrieved and associated, creating a high cognitive load. This idea correlates with the prevailing opinion on information processing in the human cognition. Our theory though, suggests, that this prerequisite of employment of increasingly complex cognitive activities opens up an equally increasing room for subsequent error, namely the “failure space”. As time moves forward and the cognitive load in traditional rule-sets ever increases - *much unlike the load in CLRC* - the failure space, interpreted as the growing difference between the two discussed approaches, grows. Hence, the behavior of the growth rate curves of both methodologies is fundamentally different. As we have explained, the acquisition of a language can just as well happen in a natural manner, through mere adoption and resemblance functionality, which is not only similar to the process of the first language acquisition - due to a total lack of a foundation language as a vehicle in order to give grammar-based instruction - but also, it appears to enable different brain activities and keep the subjectively perceived cognitive load at a much lower level, consistently so. This fundamental belief led to our advanced opinion, that the “behavior” of the failure space (in other words, the expected error-proneness and the likelihood of mismatching linguistic associations) is logically connected with the cognitive load imposed and the learner’s confidence. Based on numerous observations, tests and classroom experience, what we could see, made us to believe, that those variables highly influence each other at all times, based upon the very methodology of the instructional model. Our Cognitive Load Reduction Curriculum (CLRC) and its successful regular use supports our opinion on how the different attributes work in connective interplay. In order to visualize these opinions and their progressive interconnected behavior throughout time (which represents the progression in the acquisition process), we chose to depict them in graphs to ensure a logical comprehension of our theory. Based on that, we have then chosen to use logical equations to better express and formulate the different factors in dependency on each other, and one another, especially over time and due to the better visualization as to what would happen if one altered one or more of the discussed variables.

After all, it remains a theory, however, based on the existing research and our conducted work, we believe that not only our beliefs about the interplay of aforementioned cognitive factors are correct, but also, that in language acquisition, grammar-based instruction models lack usability in conversation in many cases, and are regularly outperformed by CLRC-styled acquisition methodologies for a number of now better-understandable reasons.

## REFERENCES

1. Anderson, J.R. 1985. *Cognitive psychology and its implications*. W.H. Freeman.
2. Baddeley, A.D. 1992. Working memory. *Science*, **255**(5044): 556-559.
3. DeKeyser, R.M. 2000. The robustness of critical period effects in second language acquisition. *Studies in Second Language Acquisition*, **22**(4): 499-533.
4. Ellis, R. 2008. *The study of second language acquisition*. Oxford University Press.
5. Krashen, S.D. 1982. *Principles and practice in second language acquisition*. Pergamon Press.
6. Long, M.H. 1996. The role of the linguistic environment in second language acquisition. *In*: W.C. Ritchie & T.K. Bhatia (Eds.), *Handbook of second language acquisition* (pp. 413-468). Academic Press.

7. Paas, F., Renkl, A. and Sweller, J. 2003. Cognitive load theory and instructional design: Recent developments. *Educational Psychologist*, **38**(1): 1-4.
8. Pashler, H., Bain, P., Bottge, B., Graesser, A., Koedinger, K., McDaniel, M. and Metcalfe, J. 2007. *Organizing instruction and study to improve student learning*. IES Practice Guide. NCER 2007-2004. National Center for Education Research.
9. Schmidt, R. 1990. The role of consciousness in second language learning. *Applied Linguistics*, **11**(2): 129-158.
10. Sweller, J. 1988. Cognitive load during problem solving: Effects on learning. *Cognitive Science*, **12**(2): 257-285.
11. VanPatten, B. and Williams, J. 2007. *Theories in second language acquisition: An introduction*. Lawrence Erlbaum Associates.
12. Vygotsky, L.S. 1978. *Mind in society: The development of higher psychological processes*. Harvard University Press.
13. Willis, J. and Willis, D. 2007. *Doing task-based teaching*. Oxford University Press.