DIFFERENTIATED LEARNING AND EVIDENCE FROM NEUROSCIENCE: SOME IMPLICATIONS FOR COMPUTER-ASSISTED LANGUAGE-LEARNING (CALL)

Ania Lian
Charles Darwin University, Australia
ania.lian@cdu.edu.au
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ABSTRACT

Recently, due to the developments in medical technology, the field of neuroscience has been experiencing an unparalleled growth, resulting in many breakthroughs in the field's understanding of how the brain learns and constructs information. The aim of this paper is to review the key findings of this research and propose implications for designing research in CALL. The findings are reviewed against the backdrop of a critique of current CALL research, which continues to show resistance to change and seems unable to offer new directions to second language (L2) pedagogues. This is a conceptual paper that hopes to inspire CALL scholars and postgraduate researchers to expand the traditional sources of the literature that define the scope of L2 studies and to integrate evidence from emerging research in order to modernise the field and its implications for practice.

Keywords: *Neuroscience, Computer-Assisted Language-Learning, second language pedagogy*

1. Introduction

In his recent publication, the inexorable rise of the proletarian autodidact, Professor Andrew-Peter Lian (2017) draws on the late eighteenth century concept of "proletarian autodidact" (Rose, 2001) to show that the exponential growth of technology currently experienced worldwide did not suddenly cause people to become interested in furthering their knowledge or their interest in the world around them, it only made the process of accessing this knowledge easier. His point was that the 21st century did not c
ate curious autodidacts; evidence from research shows that people have always had a thirst for knowledge and had always sought it. Along similar lines, since the early 1980s and 1990s, educational researchers, and specifically those in second language (L2) teaching, have advocated the concept of learner-centredness. Those early voices in Computer-Assisted Language-Learning (CALL) spoke about inflexibility of directive approaches to language-learning (Lian, 1991) and the need for diversification of learning materials to satisfy students' varied learning interests (Otto and Pusack, 1985; Pusack, 1986), needs (Lian, et al., 1993) and, as a result, to keep them interested in L2-learning.

The general belief underpinning this movement was similar to the point made by Professor Andrew-Peter Lian (2017). It was understood that children and young people in general have a natural tendency to learn and explore, a view now strongly confirmed by research in neurosci
ence and psychology stating that humans and other mammals are "wired" for exploration and play (Panksepp, 1998). However, the discussion in this paper shows that the agenda to enhance students' natural inclinations to explore and learn second and foreign languages was not enough to sustain the initial enthusiasm an
ed in technology. To provide adequate support, CALL researchers needed empirical evidence. The temptation was strong to search for answers in the most commonly used theories of learning, based in intellectual frameworks developed in early 20th century. As shown in this paper, while the field accepted the theories of Chomsky and Vygotsky as its key frameworks, it also created a culture that closed off the field to new developments, thus rendering original research in neigh-

bouring fields, such as psychology or neurosc ence, irrelevant and unnecessary.

The discussion in the sections below offers a brief review of the key paradigms of CALL research and illustrates examples of empirical findings from neuroscience that challenge the dominant beliefs of the field. Implications of these new findings are summarised in the form of principles for CALL-pedagogy and research.

2. CALL and Second Language Acquisition (SLA) research

Finding the best "fit" between what the theo ry says about the learning process and how this knowledge can be best applied in the classroom for "best results" has come to be known as bridging the gap between theory and practice (teaching). Innovation in education research was un derstood to involve scholars in using theories to generate new data that could further complement their theories and offer evidence to be used by teachers in their classrooms. This model of interaction between "theory and practice" persisted for decades despite words of caution offered by a number of prominent researchers (Biesta, A lan and Edwards, 2014; Thomas, 2007), who warned against the stifling effect that the field's preoccupation with theory construction has had on educational research and practice. Concurring with Popper (cited in Thomas, 2007, p. 95), Thomas (2007, p. 147) argued for an approach to research where alternative perspectives on practice are sought out and put into dialogue to help reveal inconsistencies and new epistemological gains that otherwise remain invisible when all types of thinking are reduced and flattened out to be described as 'theory': "there is an impoverishment brought to the exercise of inquiry".

However, critical dialogue of the kind de scribed by Thomas is rare in CALL research. The cognitive and sociocultural frameworks that underpin most of CALL studies reject dialogue in favour of conformity and dismissal of any alternative views. For example, representing the sociocultural approach, Dunn and Lantolf (1998, p. 412) argue that communication between incommensurable models is not only impossible, but also reflects a utopian dream for a single unified theory. In turn, according to the cognitive paradigm (Long, 1993, p. 228), oppositional theories, those based on radically different underlying assumptions so as to result in inco mensurable explanations of SLA phenomena, must be eliminated. The two views result in the "normalising" of the dominant theories while eliminating alternatives. Yet, the pedagogic p offs of this normalising approach to research in L2-learning are small.

The key scholars of the cognitive approach, Long (2009) and Ellis (2010), are not sure as to how relevant the findings of SLA research could be to practising teachers. Since the cognitive paradigm has offered little that teachers could use directly in an L2-classroom, Long (2009) and Ellis (2005) offer words of caution and gue for a "balanced" mix of implicit and explicit instruction, with teachers paying attention to students' "built-in syllabus" and providing "extensive L2 input" (Ellis, 2005, p. 216-217). Fo lowing this advice, Kessler and Bikowski (2011) advocate for CALL researchers to adopt a lesson design where students are expected to use sp cific conversational strategies, such as the native speaker's corrections, questions, modifications and requests for repetition, initially proposed by Long (1996), to facilitate the acquisition of grammar. The belief is that these conversational strategies can draw learners' awareness to grammatical problems and offer opportunities for self-correction in accordance with a students' own "built-in syllabus".

In order to elicit opportunities for such co versational strategies, Kessler and Bikowski (2011, p. 7) propose that teachers and CALL researchers make use of freely-available adve ture games and use diverse Web tools, such as Google maps, wikis, Skype or Moodle, to gener ate conversations on a specific topic. Kessler and Bikowski (p. 8) also mention skill-specific sof ware, such as Nanogong for pronunciation, the use of video tutorials, Hot Potatoes quizzes, and various online materials. Other than the reference to Long's conversational strategies, Kessler and Bikowski (2011) offer no new perspectives, research tools or questions that could help CALL

teachers and researchers better understand their students and the factors that impact on and interact with their learning. They also fail to contextualise Long's (1996) hypothesis in relation to modern research. The hypothesis proposed by Long (1996) draws on nativist approaches to language learning which assume that the brain processes (computes) information in a bottom-up fashion, using modules that are especially designed to accept some forms of input and i hibit the top-down expectations from "central processing" (Karmiloff-Smith, 1992, p. 3). As it will be shown later in this paper, modern research in neuroscience offers a serious challenge to Long's hypothesis. Yet, this research remains ignored and its implications to CALL studies unexplored.

As in the cognitive paradigm, the proponents of the sociocultural approach to CALL look for solutions to students' learning in conversations. In this regard, Thorne and Smith (2011, p. 268) view the concept of CALL as anachronistic and criticise the idea that digital technology can pro vide assistive support. Gebhard, Shin and Seger (2011), Blin and Appel (2011), Gonzalez-Lloret (2011) and Reinhardt and Zander (2011) suggest using digital technology as a communica tion-mediating device rather than as a tool with qualities that can be utilised for assisting learning. Consequently, sociocultural theory propo nents utilise blogs, social media, or chat rooms like Yahoo! Messenger. The overall aim is to use the context of conversation to progress students along the novice/expert continuum (Lantolf, 2000). The apprenticeship model, initially developed around the 19th century (Thomas, 2007, pp. 4-5), is rooted in the belief that all knowledge is regulated by language (Compernolle and Williams, 2016, p. 278), an idea that ignores the fact that human beings utilise multisensory processing patterns to make sense of the world. Furthermore, the apprenticeship model assumes that knowledge is passed on in some unproblematic manner from an expert to a novice (Compernolle & Williams, 2016, p. 278), again, a belief that ignores the complexity of the systems that partake in the process of meaning-making.

Guerrero and Villamil (2000) raise other issues that the proponents of the sociocultural approach ignore. For example, Guerrero and Villamil (p. 52) argue that the claim that experts have the capacity to guide a novice also evokes another claim, i.e. that the "tutor has not only a theory of how the task or problem is to be completed, but also a theory of the tutee's performance". In other words, there is really not much to investigate other than simply mapping out this intuitive knowledge. This may be exact ly why the approach shows no interest in fields other than its own. Contrary to what Dunn and Lantolf (1998) argue, the sociocultural approach practises a utopian dream giving an impression that a single unified theory can provide research with all it needs to explain, including a theory of the tutee's performance. The sections that follow will demonstrate the naivety of this belief, the complexity of the human brain and the challenges that the new empirical evidence presents to the key concepts of learning, including the con cepts of feedback or feedback comprehension.

3. Empirical evidence from Artificial Intelligence and neuroscience

Knowing how the brain tells things apart is an important question since languages present students with the problem of discerning between the elements that matter and those that do not. Supporting this process of discernment requires on the part of researchers an understanding of the processes, elements and pathways that participate in this process. The findings reported in this section show that an in-depth engagement with the literature from different fields of research, not only neuroscience, can assist CALL researchers with new insights on the process of learning and new sources of questions that can lead to more research and new developments in L2-pedagogy. The key points of this section demonstrate that how we organise and re-organise our perception does not depend on "what is", as believed dor and contested by Karmiloff-Smith (1992). Rather, these understandings are shaped and reg ulated in response to our experiences and what an organism recognises as relevant. This means an ongoing dialogue between the top and low-

level systems across sensory systems in order to minimise perception errors.

In empirical fields which concern themselves with perception, including neuroscience, psychology and Artificial Intelligence (AI), it was discovered that one of the key challenges is to understand how the brain tells things apart (Brooks, 1991). In his by now slightly dated, but highly relevant to research in L2-pedagogy, paper on building learning robots, Brooks (1991, p. 1) refers to early attempts in AI where people thought that the world was divided into neatly organised objects that could be mapped out onto the "brain" circuit of the robot to manoeuvre between the objects and to manipulate them. It was then understood that a complete representation of the external environment was an impossible task. To solve the problem, the researchers put the robot in the centre of its "world" and focused on processes that enabled the robot to learn not about the world, but about itself in its world. This shift in the method indicated a change in the thinking about robots. The robot was no longer a computing machine in a traditional sense of this word; it was an interlocutor that inhabited its world, learning to improve its own performance in relation to that world (Brooks, 1991, pp. 1-2).

In neuroscience, it was first made clear that people do not perceive the world directly when researchers learned that there is no one-neuron-one-object correspondence (Kendrick, 2010). In other words, people do not perceive objects as such. Instead, it was found that the majority of neurons responded only to very simple visual aspects, for example, lines moving in a particular direction and colours, outlines, contrasts, groupings of different features, and so forth (Kendrick, 2010). The visual world is thus broken into a myriad of component parts, and the recognition of objects, such as someone's face, involves a distributed network of neural cells bringing gether all of the different levels of analysis, from low-level to high-level components: "recognition is about the whole network being activated" (Kendrick, 2010). The networks are constructed throughout the lifetime of an individual and their distributed, multi-level structure provides people with sufficient redundancy to support recognition (Kendrick, 2010).

A similar phenomenon was observed in the perception of speech sounds. Chang's (2015) research invalidated the early notions that phonemes are the smallest and independent units of perception, i.e. a belief that was rooted in the idea that one neuron hears and recognises individual sounds. Instead, he showed that the f damental units of phonological representation are "features", i.e. small categories that the brain combines to form the speech sounds of human language (Chang, 2015). Chang showed that, as in vision, neurons work in networks that are built only when there is a good reason for their construction, i.e. when the meaning making process depends on their formation. Ramachandran and Hirstein (1999, p. 25) confirm this while pointing out that information for a person exists mainly in regions of change that people register as relevant to them (Ramachandran and Hirstein, 1999, p. 25). It follows that the construction of the low-level systems depends on the "clues" from the high-level systems that select for meaning (Fedorenko, 2015). In terms of speech, this includes associated networks which coordinate intonation, rhythm, synchrony, and other systems.

The interactions between the high-level and low-level systems of perception follow a very specific pattern. As reported by Seth (2017; 2014), people do not act on "input" as such. Rather, people respond to the world in relation to what they already know about it, not in relation to what is: it is "these top-down or inside-out connections that convey predictions from high-levels from the brain to lower levels back out to the sensory surfaces" (Seth, 2017). This finding is consistent with the understandings discussed earlier stating that reality is not perceived d rectly. The need for learning, i.e. for re-adjusting one's top-level systems, emerges when tensions are detected between what is expected and the interpretations that are formed "at each level of description" (Seth, 2017), i.e. across the whole area of the hierarchy at the same time. As Seth explains, it is not reality, or input, that we observe. Instead, the process of perception helps

people reduce the "prediction errors" between the high-level and low-level systems that organise perception. Also, to act on "input" requires that people deal with everything since anything is already a selection, i.e. a construct: "So, you can think of perception as a joint hallucination in which our perceptual predictions are being reined in at all points by sensory information from the world and the body" (Seth, 2017).

Damasio (2014) describes the multisensory nature of this process that relies on the interac tions between different systems and levels. According to Damasio (2014), the brain integrates the "images" it creates of sounds, sight, touch, of our own body, and so on, following quite a complicated process of connections, which volves manipulation of images or patterns that the brain creates from the sensory data. Once interpreted or processed, these interpretations are then sent back to the origins of those con tions (e.g. the visual or auditory systems) to be then perceived by a human as having heard or seen something. In other words, Damasio (2014) explains that people perceive hearing or seeing things only after they have already processed in formation against the multiplicity of multisenso ry connections, not before, thus negating the notion that first you see/hear and then you interpret – for him seeing/hearing are in themselves acts of interpretation. This is so much the case that in most human beings the vision will overwrite information coming to the ear and subjects hear what they see (The McGurk Effect) (McGurk and MacDonald, 1976).

4. Implications for CALL

The findings from neuroscience discussed above open new ground for CALL research and pedagogy. The principles listed below are panded by further evidence.

People are different

The principle: Since the brain does not perceive the world directly, it follows that the kinds of problems students experience are very likely to be different from one learner to the other. It is not logically possible to offer a sequenced or externally scaffolded intervention strateg ble of simultaneously meeting the needs of all (or even any one student) as it is based on the analysis/understandings of the person constructing the external scaffold: the powerful but, regrettably, not omniscient teacher. Entry points for solving individual problems are likely to be different, and perhaps even unknown, from person to person (Lian, 2004, p. 6).

Implications for CALL: Humans are multisensory beings and L2-students need to be given opportunities to interpret their learning needs with the help of tools that allow students to engage the multiplicity of these multisensory connections, utilising a diversity of systems and levels and their multiple combinations. Research studying the relationship between the acquisition of grammar and intonation showed that when this multisensory processing is prevented, our brain replaces the missing connections with what it already knows (Herrmann, et al, 2003). This may also be a reason for L1 interference. In other words, when unsupported, students are left to work with limited information and in a limited way. Consequently, the interference patterns become entrenched and are hard to break.

CALL research: In order to enhance students' learning support, research is needed to identify forms of support that utilise the capabilities of digital technology to engage students' multisen sory systems of perception to help them chal lenge the patterns already established by their first language (L1), and to enable students to build new networks that are sensitive to the new L2-patterns.

Students need personalised support

The principle: Since our perceptions systems are impacted by our experiences, it follows that students are more likely to respond to the mands of their L2-interaction by activating familiar networks and schema (Grachev, et el., 2001). It is, therefore, necessary to reduce the interference of competing information-processing demands which generate interfering conflicts in perception, attention, thinking, and memory systems and which orient the students toward always choosing the familiar, already-tested and entrenched processing pathways. To this end, students can be assisted with load-reduction fa-

cilities (Lian, 2004). Load-reduction frees the attentional space available to orient the students to recognise and process the ambiguity.

Implications for CALL: Technology can help because it can be used to design tools that help students mobilise different perceptual networks and features to compare, contrast and contest the impact of their different combinations on the problems that they experience as they grapple with a specific task at hand.

CALL research: To allow for such exploratory, expansive and transformative learning, an environment needs to provide students with portunities: (a) to explore what they know; (b) to identify the limits of this knowledge, and (c) to generate new forms of knowledge and new pos sibilities. This process is also captured by Peterson (2011, pp. 129-130):

Our ideas, lacking one-to-one correspondence with the world they represent, instead serve primarily pragmatic purposes. … If … our goal-directed actions fail, … the world confronts us with the evidence of our insufficiency … Pragmatic failure means that there was more to the thing-in-itself than originally suspected. The unmapped portion of that thing may pose a threat, but may also offer possibility for the expansion of competence. Exploration generates the info mation from which new possibilities are born.

Students solve their problems, not arbitrarily-designed learning tasks

The principle: When students' differences are respected and supported in an increasingly informed manner, students no longer deal with arbitrary problems. Instead, the learning-environment makes it possible for them to address their own interpretations of the communicative conditions that apply in the context of explora tory activities and in response to a problem at hand.

Implications for CALL: The activities and resources of the learning environment support students' subjective experiences and interpretations on which they draw to make sense of the challenges with which they are grappling. Co prehension and learning therefore are viewed as a "reconstructive process as opposed to th ple retrieval of a perfect holistic record" (Hassabis and Maguire, 2009, p. 1266). The memories, on which students draw, are their memories, and include "a sense of subjective time, connection to the self, narrative structure …, retrieval of relevant semantic information, feelings of familia ity and rich multimodal re-experiencing of the event in a coherent spatial context. (Hassabis and Maguire, 2009, p. 1266).

CALL research: It is important that the resources, which learning environments make available to the students, reflect the diversity of the world and of the classrooms' demographics. The goal is not to master forms, practices or form-meaning relationships. Rather, it is to e pand the terms in relation to which the students construct themselves with and within the world (Lian and Norman, 2017, p. 323).

5. Principles for CALL design and CALL research: Discussion

What are the implications of the principles for CALL design identified in this study? The discussion in this section offers a systematic assessment of these principles. The discussion is based around six questions developed by Lian and Pertiwi (2017) for studies to self-reflect on the innovation that they propose and the change that they seek to endorse. The questions were derived from educational studies, which are cr ical of education research and its preoccupation with "theory development" to the detriment of innovation (Biesta, et el., 2014; Thomas, 2007). The discussion below reiterates the key aspects of this critique and demonstrates the advantages that empirical evidence from neuroscience can offer to CALL and L2-teaching in general.

(a) The object of the study: What new per spectives were engaged to describe the object of study?

The principles for CALL design outlined above propose an epistemological shift in CALL studies and L2-pedagogy in general. At a glance, the principles may not appear to be new. After all, that students are different, and that they need personalised support, it has been known in L2-pedagogy at least since early 1980s. However, the concept of "student-centredness" or

"student-autonomy", first proposed by Holec (1981), offered no principled basis for teaching and research. Those early conceptions of learner autonomy persist until today, with research defining autonomy as the "ability to take charge of one's own learning" (Holec, 1981, p. 3; 1995; Oxford, 1990). Along similar lines, Little (1991, p. 8), Littlewood (1997, p. 72), and Nunan (2004) talk about the importance of students being involved in the decision-making process regarding what they are studying and how, with teacher input being minimised. However, how exactly students are to be involved in this process of decision-making is not specified. This vagueness of definitions leads Schweisfurth (2011, p. 425) to believe that, ultimately, learner-centred pedagogy is a Western construct, "inappropriate for application in all societies and classrooms".

As indicated in the CALL examples discussed above, researchers from both the cognitive and the sociocultural paradigm focus on activities, CALL-based or not, that provide conditions for feedback that is attuned to a learner's or a group's developmental needs (Compernolle and Williams, 2016, p. 278). For the cognitive paradigm, these developmental needs relate largely to the lexicogrammatical system. For the sociocultural research, these needs may include an L2 feature, skill, or concept. In any event, each paradigm constructs the object of students' learning in terms that are derived from their perspective on what the learning involves, never from the students' perspectives. Yet, the empirical evidence from neuroscience shows that students organise information according to their experiences, not those of their teachers or a specific theory of L2-acquisition that a teacher decides to follow. In other words, students learn what is meaningful to them, not objects of theoretical facts. This is a critical distinction: if students build meaning-making patterns, it would follow that the job of L2-research is not to impose its meaning-making models onto students, with a view to developing a theory of L2-acquisition. Instead, L2-research should identify conditions that help students challenge, structure and restructure the interpretative schemes that inform their L2 actions.

(b) The method of study: What new understandings were identified to devise the method of investigation?

All empirical evidence cited in this paper is new to L2-research and illustrates arguments against the cybernetic (Wiener, 1948) model of reality, where the process of meaning-construction involves storage and retrieval of pure information that is free from the prescriptive and evaluative statements of their "programmer" (Birdwhistell, 1970, p. 67). The evidence shows that the brain does not respond to "pure" signals, endowed with precise meanings. The brain constructs the signals by creating patterns from a variety of sensory features that it detects as relevant. Following on this point, the brain is not a "naturally good producer of logical thoughts composed of words with precise meanings which it emits under proper stimulation" (Birdwhistell, 1970, p. 66). That is, it does not wait for the right signal to match its "built-in syllabus" (Ellis, 2005, p. 216-217). Instead, empirical evidence from neuroscience points to exploration as a key mechanism by which students can build increasingly stronger L2-systems by comparing and contrasting the interpretive value of the schema on which they act in L2-contexts and which inform their L2-models.

Further justification for exploration comes from the structure of the brain itself. According to Peterson (1999), the right and the left hemispheres have very different functions, each endowed with a facility to deal with the more familiar and the unfamiliar. While the right hemisphere governs humans' initial responses to the unknown, the left is more suited for actions undertaken while people know what they are doing (Peterson, 1999, p. 63). When a conflict or an unfamiliar context is detected, the initial response is to freeze, then to imagine what the context may involve, next the brain engages in an exploration of the context, differentiates information and then masters that "which worked" (Peterson, 2017). The interaction between the two hemisphere describes the process by which the brain transforms low resolution repres

tions of the unfamiliar into high resolution rep resentations enable a person to better discern and to build increasingly powerful interpretive schema: "the exploratory capacity of the brain "builds" the world of the familiar (of the known), from the world of the unfamiliar (the unknown)" (Peterson, 1999, p. 37). It follows that in order to support L2-learning, L2-studies should focus on facilitating this exploratory process. This is a very different method of conducting research than simply recording changes in students' lan guage production and interpreting these changes as "development". The huge storage capacities of modern computers, when combined with their random-access facilities, provide researchers with a great deal of malleability that can be used to develop tools enabling students to challenge the ways in which they create meaningful co nections when interacting in another language.

(c) The beneficiaries of the study: Who was the beneficiary of the study? What new under standings of the research participants' contexts were engaged and how were they impacted by the study?

The findings from neuroscience show individuals to be meaning-makers, engaged in an internal dialogue in order to make sense of the impact of their interactions with the world. In view of these findings, it is important to draw a distinction between two types of L2-learning research. Developmental research, or Second Language Acquisition (SLA) research, is interested in the task of mapping L2-development. To this end, it designs learning opportunities, CALL-based or not, to test its own theories. This is theoretical research and, despite its popularity among teachers, it frequently distances itself from L2-pedagogy (Gregg, 1996). Its main purpose is not to serve the students, but to examine its own theories. It would follow that pedagogic research should concern itself with students and, specifically, with the questions (or challenges) that students experience when grappling with an L2-problem at hand. Since no theory of L2-learning can provide sufficient insights to capture the complexity of these subjectively experienced questions, it is important that pedagogic research designs tools that help students find their own answers to these questions.

Lian and Pertwi (2017) refer to Lian, et al., (2017) pedagogic study to illustrate its inn vative use of technology in L2-learning. The study developed a technology-based tool for assisting students in the process of developing their academic writing skills by helping them compare and contrast aesthetic qualities of different texts in English, and across languages, in order to support students in making informed and creative choices when creating their own texts. The tool is a learning support, not a teaching device. The design draws on a variety of evidence from a diversity of disciplines that offer insights on the factors that impact on and interact with the learning process. The goal behind the study is not to apply and measure students' learning in accordance to a specific theory of learning. Rather, it is to help students challenge, explore and expand their interpretive schemes in L2, and measure the extent to which this was achieved. It is not that clear that pedagogic research would ever result in a developmental theory of L2-learning, nor is it a priority. Most likely, pedagogic research will give rise to a collection of insights, linking a diversity of frameworks and concepts, together illuminating various aspects of the L2-learning process: a goal that Biesta, et al. (2014) and Thomas (2007) identified as the sirable direction for education research.

(d) The critical perspective: How was the world integrated into the study?

The discussion thus far presents research in L2-pedagogy, including CALL-studies, with an epistemological and ontological challenge. The evidence compiled in this paper and the arguments in this section make a case for a separation of pedagogic L2-research, including CALL studies, from developmental research. This separation is important since L2-learning is not exclusively a cognitive process and students do not experience theoretical problems. Students are emotional beings and their actions are responses to challenges that, primarily, are experienced at the level of emotions, not

cognition per se. Emotions are subjective sensations that are experienced when one encounters a situation that has implications for action, i.e. that has a motivational significance (Peterson, 1999, p. 20; Damasio, 1994). Since L2-learning concerns itself with "how to act", and therefore also with the values that justify action, students experience L2-reality, and themselves in an L2 situation, as a place to act.

The challenges that students encounter are interpreted in emotional terms and need addressing in the form of processes by which their internal conflicts might be transformed into that which is desired and therefore meaningful (Peterson, 1999, p. 23). This link between learning and emotion has implications for both task design and feedback. When learning experiences are constructed around goals that are motivated by a specific theory or perspective on learning, students' subjective realities are eliminated from consideration and replaced by an external point of view. On the other hand, when students' subjectivity is seen as primary, theoretical concepts and models are integrated into the learning environment to enhance students' motivations and investment in the learning process, and to sup port the transforming effects that learning can have when individuals better understand their own position in the contexts that affect them.

(e) The political perspective: How were the policies integrated into the study?

The present paper invited readers to critically reflect on the status of research in L2-pedagogy and, specifically, of the frameworks that support developments in CALL. At the time when ASEAN member countries make L2-learning a pri ity, it is important to critically assess the progress achieved thus far. Just recently, in 2015, the Vietnamese government carried out an extensive training of English university and school teachers in CALL: the 2020 program. Investments of this kind are on an increase and careful consideration of the expectations is needed. The present paper sought to propose a number of questions to assist this process. Among those questions are concerns with the intellectual scope in which CALL research is being framed, the range of empirical evidence on which researchers draw, and, most of all, the place of L2-learner in this research.

(f) The generative perspective: What new forms of practice emerged as a result of the new ways of theorising?

The discussion thus far has offered a strong argument for a shift in CALL studies, away from the traditional preoccupation with bui ing a theory of learning, toward a study of factors that impact on and interact with learning to support meaningful and emotionally rewarding learning experiences. However, the integration of the principles for designing CALL environ ments summarised in this paper is not without its challenges. In some way, the cognitive and the sociocultural approaches to L2-research have offered scholars a comfortable framework for doing research, thus reducing the need to search for evidence and concepts in different disciplines that might challenge the status quo. This sense of comfort has also reduced th riosity of the field, had a limiting impact on the imagination of CALL scholars, and has left the field with only sporadic examples of how evidence from fields such as neuroscience could be integrated to result in creative proposals to be tested and further developed. The danger is that, as neuroscience expands its impact on L2-learning, it may take a while before researchers become skilled in working with new ideas in a critical manner.

6. Conclusion

This article began with a question about the forms of learning environment where technology could be used to support L2-students in achieving their best while also feeling achievement as they engage in their learning. The discussion of this paper pointed out to the limitations of the research paradigms which currently dominate L2-pedagogic research, including CALL stud ies. The author showed that the cognitive and the sociocultural approaches draw on research tr ditions where the primary interest is to develop a specific theory of L2-learning. It was argued that in those paradigms, students are secondary to the task of building a theory. The author con-

trasted this goal with research where the priority is to learn about the factors that impact on and interact with learning. The advantage of the latter model was in its insistence to search for a diversity of clues that may provide CALL r searchers with additional information about the ways in which technology could be used to support/assist students' learning experiences.

The author suggested that the overwhelming focus on theory-development was counter-pr ductive to the discipline of L2-pedagogy, which at its core has the interest of the student, not of a theory. It was argued that in order for the disci pline to change its current direction, it is important for researchers to expand the sources of evi dence on which they build their understanding of CALL and students' engagement in CALL. The author looked predominantly to neuroscience as a source for such alternative evidence. Neuroscience has been experiencing recently significant growth, but its impact on CALL is limited to a handful of studies, if that at all. On the basis of the evidence from neuroscience, the author developed a number of principles for CALL research and pedagogy. The implications developed in this paper on the basis of these findings confirm long-established sentiments in L2-pedagogy that people are different from one another and that they need personalised support which allows them to solve their problems, not learning tasks that have been arbitrarily co structed by teachers. Personalised environments also require rich resources reflecting the local and global contexts of students' participation in the world.

Together, the brief critique of the key mainstream CALL paradigms, the findings from neuroscience, and the proposed framework for CALL research demonstrate that CALL has a far greater role to play in students' learning than being simply a communication mediating tool. Future research and innovation in CALL will depend on the capacity of its researchers to en gage in complex, cross-disciplinary dialogues that result in imaginative and exciting projects, new frameworks and concepts, and, especially, a form of leadership that the field is currently lacking.

Conflicts of Interest:

The author declare no conflict of interest

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