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学位授与の日付	2020 年 3 月 31 日
論　文　名	**Embodied Conversational Agent to Enhance Second Language Learners' Willingness to Communicate** **第二言語コミュニケーション意欲を高める会話エージェントに関する研究**
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(別紙 1)

論文要旨

学位論文提出者氏名　Emmanuel Ayedoun

学位論文題目　Embodied Conversational Agent to Enhance Second Language Learners' Willingness to Communicate

One fascinating area where traditional educational systems are still struggling to make a significant impact on learning outcomes is second language acquisition, more specifically as far as its communicative aspects are concerned. The primary purpose of second language (L2) learning is to provide learners the ability to autonomously convey their intended meaning effectively in the target language and, by extension, to facilitate exchanges between people from different countries. However, a pressing issue is how to encourage learners to use L2 for communication, because many students do not naturally engage in much L2 production, either inside or outside the classroom, even after studying the target language for several years. Moreover, some L2 learners, despite excellent linguistic competence, tend to avoid using L2 for communication, whereas others with only minimal linguistic competence seem to communicate via L2 whenever possible. The literature suggests that the key factor for ensuring a spontaneous and sustained L2 use is the willingness to communicate (WTC) in the L2, which is defined as a "readiness to enter into discourse at a particular time with a specific person or persons, using an L2". It has been found that L2 WTC is influenced by context-dependent and complex interplay of emotional variables such as confidence, anxiety, desire to communicate, etc. Studies have also shown that learners displaying high WTC are more likely to show more considerable improvement in their communication skills and acquire higher levels of language fluency than those with low WTC.

To help overcome the lack of suitable environments for increasing L2 learners' WTC, this dissertation sheds lights on the design, implementation and evaluation of an **embodied conversational agent-based simulation environment** dedicated to providing L2 learners with realistic opportunities to freely simulate daily conversations, whereby to alleviating emotional variables that inhibit their motivation towards communication in L2.

In more concrete terms, the main research questions addressed in this thesis are as follows:

Can a computer-based spoken dialogue environment be useful for enhancing L2 learners' WTC? (Chapter 3)

Computer-based learning support systems that target learners' engagement towards communication in particular, remain a conspicuous rarity in the literature and less effort has been expended on investigating the usage of realistic virtual interfaces, such as embodied conversational environments, which seem to have the potential to be a suitable alternative to face-to-face authentic interactions. In the lights of such a situation, we designed and implemented an **embodied conversational agent (CEWill)** to provide L2 learners with opportunities to simulate realistic daily conversations, thereby to mitigate their apprehension of communication using their second language. CEWill was built following a modular approach, which made possible the integration of several third-party cloud-based services to our hand-crafted modules. A pilot experimental evaluation suggested that frequent interactions with the system could have a positive influence on the key factors predicting WTC among L2 learners. In addition, the results also suggested that the degree of reality of interactions held with CEWill was high enough to enable a good immersion of learners in the conversation context provided by the system. These preliminary results were seen as an important milestone confirming the meaningfulness of our research approach, and a solid foundation to build on.

Which scaffolds to implement towards targeting emotional variables that influence L2 WTC? (Chapter 4)

Based on the promising results achieved with CEWill, we focused on investigating ways for strengthening the impact of the proposed system on emotional variables influencing L2 WTC. To such extent, we designed a

novel **dialogue management model (DiMaCA)** based on two conversational strategies, namely **Communication Strategies (CS)** and **Affective Backchannels (AB).** DiMaCA was introduced to enhancing CEWill ability to deliver communicative and affective feedbacks at appropriate times of the interaction, in order to help L2 learners acquire and maintain higher levels of motivation towards communication. More concretely, by enabling CEWill to make use of CS, our idea was to enhance the embodied conversational agents own strategic competence to release learners from the challenging and WTC-inhibiting burden of resolving communication pitfalls by themselves. By selecting and implementing a particular set of backchannels (i.e., AB), we aimed to foster the agent's ability to convey empathetic and WTC-friendly support to learners.

An experimental evaluation of the proposed approach showed that combining both scaffolds (i.e. CS and AB) empowers the embodied conversational agent, making possible significant WTC outcomes among L2 learners. These results provide evidence on the feasibility and meaningfulness of enhancing L2 learners' engagement towards communication using a computer-based environment coupled with appropriate conversational strategies.

How to provide an adapted level of WTC support according to learners' characteristics? (Chapter 5)

Although the importance of scaffolding is well acknowledged, proposing systems that address variations in student expectations and interests and providing an adaptive level of support remain major challenges in the field of technology-enhanced education. Keeping in mind a long-term perspective in the support to be delivered by our proposed conversational environment, we investigated the feasibility of and proposed approaches for achieving an **adaptive deployment and withdrawal of CS and AB** according to L2 learners' WTC level and scaffolds preferences. To such extent, we took a closer look at learners' perceptions of the support provided by each of or combination of these motivational scaffolds and closely investigated differences in preferred strategies according to learners' WTC levels. We further investigated how these differences correlate with learners' WTC outcomes after interacting with the system. We found that depending on the level of motivation towards communication (i.e. WTC level) reached by L2 learners, they tend to prefer certain types of scaffolds, which in turn seem to work better to stimulate their readiness for communication in the target language. Such results suggest the feasibility and meaningfulness of progressive scaffolding and fading of employed motivational scaffolds (i.e., CS and AB), by taking as reference learners' preferences for scaffolds as well as their WTC level. We also highlighted the novelty of the concept of **such fading of motivational scaffolds**, which seems to be relatively different from the notion of fading as it is conceived in traditional cognitively intelligent tutoring systems.

In addition to those above three main contributions, this thesis also presents new research perspectives towards facilitating cost-effective diffusion of the proposed approach over several dialogue situations (Chapter 6).

Given that L2 learners' decision to initiate speech varies over time and across situations, a desirable conversational environment should offer learners the possibility to converse efficiently in a variety of different social conversations situations. However, implementing a realistic conversation scenario in a given domain (e.g. restaurant, hotel, flight booking) could easily turn out to be a time and resource-consuming activity that requires significant knowledge-engineering effort and some degree of expertise about dialogue systems and the domain itself. Thus in order to solve such issue and allow actual educators and other stakeholders to actively take part in the system design process, we proposed a **conceptual framework dedicated to ease the design of dialogue scenarios**, as a basis for the development of an authoring tool that could facilitate the rapid implementation of our proposed embodied conversational agent (CEWill) over various dialogue situations. The originality of the proposed approach lies in our adoption of **a generic model of services process structure** to make possible rapid specification of dialogue scenarios in various service domains. A conceptual authoring workflow is presented to show the feasibility of the approach. The achievement of such a framework is expected to ultimately promote

the availability of a richer pool of conversation simulation opportunities for L2 learners, and contribute to the diffusion of shared dialogue systems design principles, especially for studies dealing with communicative aspects of language acquisition.

In countries like Japan, where second language (i.e. English) learning focuses less on the development of communicative skills, and where learners have limited access to opportunities for practicing the target language, the promising results presented in this thesis provide insights on **the meaningfulness of integrating embodied conversational agents** in the traditional teaching curriculum.

Moreover, from a higher point of view, this work was driven by the motivation to propose educational systems that are able to **go beyond cognition**, and the interest of identifying which key attributes of computer systems and particularly embodied conversational agents are susceptible of **influencing learners' emotions**, and creating a **friendly and engaging learning environment.**

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学位論文審査結果の要旨

学位論文提出者氏名　Emmanuel Ayedoun

学位論文題目　Embodied Conversational Agent to Enhance Second Language Learners' Willingness to Communicate

本学位論文は，人工知能分野における知的対話エージェントとそれを援用した学習支援に関するものである．知的対話エージェント(計算機)との英会話を通じてヒトの第二言語会話意欲の向上が図れるか？という問いを掘り下げて研究したもので，以下の 3 つのリサーチクエスチョン(以下，RQ)に対する解を得るものである．

RQ1 対話エージェントとの英会話体験がヒトの第二言語会話意欲の向上に資するか？
RQ2 第二言語会話意欲の向上に資する会話システムとして備えるべき会話戦略は何か？
RQ3 第二言語学習者の特性に適応可能な会話機構の実現方法は？

RQ1 に関して，迫真性のある疑似体験が可能なことを確認するとともに，学習者の第二言語会話意欲への肯定的効用を確認している．

RQ2 に関して，独自に開発した 2 つの会話戦略，すなわち，会話タスクの遂行支援を意図した CS (Communication Strategies)と情動支援を意図した AB (Affective Backchannels)が，第二言語会話意欲の向上支援に有効であることと，2 つの会話戦略の相乗作用を確認している．

RQ3 に関して，2 つの対話戦略を併用することがいずれの学習者の第二言語会話意欲の向上にも寄与することを明らかにした．その上で，いずれか一方の戦略を用いる場合には，会話意欲が相対的に高い学習者には AB よりも CS，低い学習者には CS よりも AB が効果的であること，さらには，戦略に対する嗜好性と意欲向上に対する効果が一致することを明らかにした．すなわち，ヒトの第二言語会話意欲と戦略への嗜好性の違いにより，計算機が採用する会話戦略の効果が異なることを明らかにしている．このことから，AB と CS の 2 つの戦略を併用することを基本としつつ，学習者の会話意欲，嗜好性に基づき，会話戦略を適応的に変化させていくアプローチの有用性を示唆している．

上記の成果について，本学位論文審査委員会は，人間社会システム科学研究科現代システム科学専攻の博士論文審査基準に照らして厳正な審査を行い，以下の評価と結論に至った．

1） 博士学位申請者が主体的に取り組んだ研究であること．

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本研究は，博士学位申請者が学域 3 年次に研究テーマとして設定したもので，以来，入念な調査に基づいた研究計画を策定し，システム実装，評価実験，論文執筆などに申請者が主体的に取り組んだ研究であると認められる．

2) 研究内容に新規性および独創性を有していること．

2 つの対話戦略，CS と AB を実装した対話システムはこれまでにない．さらに，それぞれの対話戦略と第二言語会話意欲向上との関係を明らかにした研究もなく，研究内容に新規性および独創性を有している．

3) 当該研究分野の発展に貢献する学術的価値が認められること．

2)の結果は，計算機とヒトの間で情動伝染が生じることを計算機に組み込む会話戦略との関係で明らかにしている点で学術的価値が認められる．この成果は，ヒトとソフトウェアエージェントあるいはヒトと実像を備えるロボットとの間でなされる対話特性の違いや，介護や学習支援などの様々な領域の特性を踏まえた対話戦略モデル構築の基礎となる学術的成果であり，人工知能における対話システム研究，ヒューマンコンピュータインタラクション研究，学習支援システム研究などの分野における研究テーマの創出と発展に貢献する学術的価値が認められる．

4) 論文の構成及び内容が適切であり，論文としての体裁が整っていること．

・ 先行研究を含めて研究背景および課題が記述され，研究目的が明確であること．

本研究は，人工知能分野における対話システム研究や教育システム情報学，認知心理学に関する知見に基づいた学際研究である．認知心理学研究において，学習支援文脈での情動支援の重要性が指摘されているものの，教育システム情報学研究のほとんどが認知支援研究に焦点化した研究に留まっている課題を指摘している．さらに，第二言語教育研究の領域において，会話意欲の向上を目掛ける研究が必ずしも多くない課題を指摘し，対話システムを活用した第二言語会話意欲向上支援を研究目的としている．先行研究を含めてこうした研究背景および課題が記述され，研究目的は明確である．

・ 研究方法が明確に記述され，研究目的を達成するために適切なものであること．

3 つのリサーチクエスチョンそれぞれに応えるための会話システムの実装・制御方法および実験計画は，先行研究の知見に基づいて十分に吟味され明確に記述されている．

・ 結果およびそれに対する考察が論理的に記述され，研究目的に対応した結論が適切に導き出されていること．

データ解析法については，共分散分析などの統計的分析に基づき議論しており，これまでの基本文献や調査データを十分に吟味して論理的に結論を導出している．

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・ 文献が適切に引用されていること．

対話システムにおけるアニメーション型会話エージェントに関する文献(19 本), 対話マネジメント機構に関する研究論文(15 本), 教育場面における対話システムの活用に関する文献(22 本), 認知心理学に関する研究論文(17 本), 第二言語習得における会話意欲に関する研究論文(26 本), その他関連論文(47 本)が引用されている．総計 167 本の論文がそれぞれの観点から適切に引用され，研究を位置づけている．

5) 学位論文の公聴会での論文内容の発表および質疑応答が論理的に明確に行われていること．

公聴会での論文内容の発表は，リサーチクエスチョンと解，および得られた成果の価値が論理的かつ明確に述べられた．質疑応答も論理的かつ適格なものであった．