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DIGITAL-GAMING TRAJECTORIES AND SECOND LANGUAGE DEVELOPMENT

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Recent research in digital game-based language learning has been encouraging, yet it would benefit from research methods that focus on the gaming processes and second-language development (Larsen-Freeman, 2015) rather than learner/player reflection or individuals' beliefs about the validity of gameplay. This has proven challenging as research methods which provide insight into the gameplay experiences and its many factors are needed. Having the gameplay experience occur extramurally is desirable, but makes the direct observation of the learners' activities by a researcher difficult. For this reason, we suggest approaching digital game-based language learning through complex adaptive systems research (Larsen-Freeman & Cameron, 2008a) and employing Dörnyei's (2014) retrodictive qualitative modeling to capture the complex synchronic and diachronic variability of the learners and their individual nonlinear gaming trajectories with requisite data density and over a considerable period of time.

This article draws on a study examining language learners playing the online role-playing game *World of Warcraft* over four months. We will focus on the data collection in this observational study and the methods of analysis of a complex adaptive system, which helped to better understand the role of extramural digital gaming for the purpose of second-language development.

Language(s) Learned in this Study: German

Keywords: Game-based Learning and Teaching, Research Methods, Virtual Environments

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ON THE USEFULNESS OF DIGITAL GAME-BASED LANGUAGE LEARNING

Digital game-based language learning (DGBLL) has been theorized and analyzed using a diverse range of theories and methods. A similar trend is evident in computer-assisted language learning (CALL) research in general, as CALL has benefitted from scholarship applying many theoretical frameworks (Hubbard, 2009) such as the interaction hypothesis (Chapelle, 2005; Smith, 2003), activity theory (Blin, 2004), and sociocultural theory (Thorne, 2008). DGBLL has yet to be analyzed with this level of diversity; research has focused either on the qualities of games which are most relevant to language learning (e.g., Gee, 2008, Sykes & Reinhardt, 2012) or on the language learner's self-reported perceptions of the efficacy of gameplay for second-language development (SLD; see Larsen-Freeman, 2015) purposes (e.g., Allen, Crossley, Snow, & McNamara, 2014; Peterson, 2012). The growth of DGBLL is impressive (see Cornillie, Clarebout, & Desmet, 2012; Peterson, 2013; Reinders, 2012; Sykes & Reinhardt, 2013). Various studies examined either vernacular massive multiplayer online role-playing games (MMORPG) or their educational-variety, synthetic immersive environments (Sykes, Ozkoz, & Thorne, 2008). In the majority of these studies (e.g., Peterson, 2012; 2013; Rankin, McNeal, Schute, & Gooch, 2008; Reinders

& Wattana, 2012; Suh, Kim, & Kim, 2010; Zheng, Newgarden, & Young, 2012; Zheng, Young, Wagner, & Brewer, 2009), participants are being observed by researchers while playing the game. This potentially detracts from the authentic and common experience of gameplay at the player's leisure and at a preferred location, while at the same time limits the amount of time a player could potentially want to play (for an example see Bytheway, 2014). Research by Rama, Black, Van Es, and Warschauer (2012) is one exception to the majority of these studies; the authors allowed participants to play the game at their own discretion. With gameplay session lengths being restricted by the amount of time the researchers can afford or the amount of scheduled time in the classroom, it is very challenging to determine trajectories of gameplay and SLD, robust learning outcomes, and diachronic and synchronic learner variability. Peterson (2012) called for studies that are removed from the classroom to be conducted.

SLD that occurs while playing and interacting with a digital game must not only be useful in the game itself. Rather, the learner-centric nature of game-based learning can facilitate the transfer of linguistic constructions to other contexts. This transfer of knowledge and skills or abilities has been observed since the early days of game design—for example, with game skills leading to a better mastery of scientific simulations (Prensky, 2001). Separated into two distinct categories, transfer can be defined either as far transfer (transfer to a dissimilar context or topic) or near transfer (transfer to a similar context or topic; see Barnett & Ceci, 2002). Text-heavy DGBLL lends itself well to the transfer of linguistic constructions. Although the environments vary, the ability being developed—second-language proficiency—is applicable independent of the context. As Tobias and Fletcher (2011) stated, "transfer of knowledge, skills, and attitudes from games to tasks in school or training contexts, or to activities in life generally, is of central significance for the effectiveness of games in delivering instruction" (p. 161). To argue for the usefulness of DGBLL is therefore to argue the efficacy of transfer from the game environment to various external contexts. Transfer is, however, ultimately difficult to substantiate and is multi-determined: "although various forms of transfer occur…success depends on certain aspects of the situation, including the content to be transferred and the context to which it is transferred" (Barnett & Ceci, 2002, p. 632). In our study, we focus primarily on the near transfer of linguistic constructions from the game play to a group conversation about gaming experiences.

Piirainen-Marsh and Tainio (2009) focus primarily on how learners playing digital games and embodying the characters can transfer the language from the game environment to in-person conversations with one another. Specifically, "by repeating, anticipating, and recontextualizing the avatars' lines, or creating their own lines, the players demonstrate not only their close attention to detailed features of the game language, but also the relevance of language expertise to the competent management and enjoyment of the game" (p. 172). These iterations are integral to the successful transfer between contexts. What begins as repetition is found to extend to actual transfer through multiple iterations, as players frequently borrow the in-game language in subsequent conversations with one another removed from the synchronous gameplay experience.

In various studies (Jakonen, 2014; Kobayashi, Kobayashi, & Fujimura, 2014; Neville, Shelton, & McInnis, 2009), near transfer is operationalized differently, although overwhelmingly it is through students' gains in vocabulary. The studies which examine other transferable aspects from gaming to non-gaming contexts, such as strategy use (Peterson, 2010) and more general skills within educational settings (Delwiche, 2006), appear to find it challenging to explicitly define and observe the near transfer that occurred during the study, especially when the gameplay is confined to a classroom setting without the possibility for extended gameplay sessions.

In our study of volunteer university students playing *World of Warcraft* in German over four months to further their SLD, we are using the near transfer of linguistic constructions as a robust indicator of SLD that emerges from the individual gameplay trajectories. In our article, we will present only a sketch of the conceptualization of both game-playing and SLD as complex adaptive systems (CAS; see Larsen-Freeman & Cameron, 2008a). Here we will focus mainly on the methods of analysis of CAS and will

instantiate these in our discussion of this study. The main research question that guided our analysis is as follows: How do language learners' trajectories of gameplay interact with their trajectories of SLD?

AN APPROPRIATE THEORETICAL PARADIGM

Larsen-Freeman (1997) has introduced CAS to researchers in applied linguistics. Since about 2007, we have seen a proliferation of theoretical essays and empirical studies that conceptualize instructed language-learning processes and SLD as CAS. However, there has been little CAS research in CALL, although a number of scholars have stated the importance of such approaches and their appropriateness to CALL research (e.g., Colpaert, 2013; Schulze & Scholz, 2016). Prior CAS research in CALL can be summarized briefly. Sockett (2013; see also Sockett and Toffoli, 2012) studied the strategies of students learning English online informally and based the analysis on the characteristics[1] of CAS. Thorne, Fischer, and Lu (2012) analyzed texts in online multiplayer games and their affinity spaces (subordinated wikis, chats, discussion boards, etc.; see Gee, 2005) as complex semiotic ecologies. Liou (2012) conceptualized learners' interactions in *Second Life* as a CAS; and Marek and Wu (2014) claim that a CAS approach should be used in CALL instructional design. These are examples of CAS having made inroads in CALL research. We submit that research on CAS in CALL can provide an integrative, non-reductionist, and contextualized perspective on technology-mediated SLD.

Technology-mediated SLD in CALL is a complex, nonlinear process. It is complex because of its multiple variables, components, and actors. These are interconnected, interact with one another, and often change dynamically in the process. CALL processes are nonlinear because their trajectories reflect sub-processes such as developmental spurts, backsliding, and plateaus. Teachers and learners alike have known this all along, but many research studies and pedagogic interventions have relied and still rely on assumptions of binarity (in the end there are always only two—erroneous and correct, effective and not effective, or pre-test and post-test, etc.—and these two are clear opposites) and linearity (there is a proportionate relationship of cause and effect and processes move in one clear direction; see also Dörnyei, 2014; Larsen-Freeman & Cameron, 2008b). The conceptualization of processes in CALL—game playing, collaborative online writing, chat, interacting in a virtual world, and so forth—as CAS means we are moving away from reductionist binary and linear views of SLD. Of course, language and language use are also CAS. Language use and language development on both the individual plane and the social plane are inextricably interconnected.

Conceptualizing SLD and second-language processes in CALL—in our case the individual learner's gaming interactions in *World of Warcraft*—as CAS is central to our research. A thorough understanding of the nature of CAS is therefore an essential prerequisite. As a brief introduction to CAS, we list its main characteristics (de Bot & Larsen-Freeman, 2011; for a detailed discussion in the context of CALL see Schulze & Scholz, 2016; Sockett, 2013):

- sensitive dependence on initial conditions;
- complete interconnectedness;
- nonlinearity in development;
- change through internal reorganization and interaction with the environment;
- dependence on internal and external resources;
- constant change, with chaotic variation sometimes, in which the systems only temporarily settle into *attractor states*;
- iteration, which means that the present level of development depends critically on the previous level of development; and
- emergent properties

Extrapolating from these characteristics, SLD in CALL has to be considered in context and over time; the variability of the development of individual learners over time and within groups always has to be taken

into account and should not be leveled. Language and development are emergent phenomena; the interaction of smaller variables and components can result in change into a larger entity of different quality. Change that occurs in these processes and that is often reflected in process outcomes is a complex phenomenon. It depends on complex configurations of variables, and the relationship between the conditions and the results of change is disproportionate, resulting in nonlinear developmental trajectories.

We can observe the behavior of individual language learners—in their groups—over time and distinguish developmental patterns and infer information about individual cognitive variables, but we need to be aware of the limitations of these inferences. Although we view CAS as deterministic, we are aware that their cause–effect relationships are complex and often disproportionate. Individual developmental trajectories are, therefore, frequently unpredictable by observers (Dörnyei, 2014). In other words, it is impossible to predict all future states of a CAS or the state in which the system comes to a rest—that is, the end state of language learning. Thus, the predictive power of complex systems theory is limited, certainly in such complex social systems as digital gaming and SLD. However, this theory has considerable explanatory power.

METHODS FOR THE ANALYSIS OF COMPLEX ADAPTIVE SYSTEMS

CAS theory welcomes the variability of actors, components, and variables in a system and its context and the change that results, so a commensurate set of methods have to embrace this variability and change, not eliminate it through experimental design or statistical computation or level it in cross-sectional considerations of arithmetic means. Consequently, a research design of experimental and control group is seldom necessary, and pre- versus post-test designs are often insufficient to capture the nature of complex developmental processes. Instead, analyses have to go through a number of iterations and data sets have to be gathered over time and include data of sufficient density. Individual learners are considered individually *and* in the context of their group. The different states of one learner's CAS are investigated and compared iteratively. Commonalities and differences matter in that both provide clues about where and how the change was induced and influenced. These individual processes (e.g., digital gaming sequences and episodes of second language use) are then compared again iteratively with similar states of the CAS of other learners.

Investigating Individual CAS Characteristics and Collective Variables

CAS analysis is detecting, localizing, describing, explaining, and interpreting change. Therefore, we can identify the specific instantiations of the eight CAS characteristics of the system under investigation:

1. What are the initial conditions for each technology-mediated language-learning activity? What aspects of change in the interaction showed sensitivity to or depended on the conditions that influence the CAS during the most iterations?
2. What collective variables, actors, artifacts, and other components induced, influenced, and sustained change and development of aspects of each language-learning activity? In which way are the variables, actors, artifacts, and components connected with each other?
3. What are the trajectories of the activity as a whole and of (research-relevant) collective variables specifically? Which (fractal) patterns of change can be identified in the trajectory of an individual and across individuals?
4. What change occurred during the CALL activity? What were the processes and outcomes of the corresponding self-organization of the CAS and of its interaction with the environment?
5. Which internal and external resources led to change in this activity and how did they do so?
6. What is the general nature of the change in the CAS? Which attractor and repellor states can be identified? What can these phase spaces tell us about the nature of the CAS?

7. What are important iterative sub-processes of the technology-mediated language-learning activity? How does a particular iteration introduce change?
8. What properties of the activity emerge in its course, and how do they *change*?

All eight question complexes require the definition and operationalization of CAS-essential and research-relevant variables. Although all variables may not receive equal attention in an analysis of a specific CAS, they are potential factors to consider. Indeed, attempting to analyze everything that occurs within a CAS may be challenging (see Marek & Wu, 2014). To reduce the high number of degrees of freedom of the CAS, we—as Larsen-Freeman and Cameron (2008a)—adopt a technique from molecular dynamics: *collective variables*.

> It is frequently the case that the progress of some…process can be followed by following the evolution of a small subset of generalized coordinates in a system. When generalized coordinates are used in this manner, they are typically referred to as reaction coordinates, *collective variables*, or order parameters, often depending on the context and type of system. (Tuckerman, 2008, n.p., emphasis added)

Collective variables, such as *proficiency* and *motivation*, are thus dynamic configurations of smaller variables and are essential to describing the developmental change of the CAS. Although collective variables consist of a number of smaller variables, they can be operationalized as a unit. Observing a few collective variables in their context while paying attention to significant occurrences of change in the CAS, we get a reasonably comprehensive depiction. The only downside is that the resulting depiction might be of coarser granularity.

Retrodictive Qualitative Modeling

Two considerations are particularly important when it comes to identifying commensurate methods: (1) long-term, multivariate analyses of language-learning processes are necessary and (2) the complexity of CAS and, consequently, the difficulty with and the low likelihood of predicting its future states accurately mean that we need to employ (qualitative) retrodictive methods of analysis (Dörnyei, 2014). Retrodictive (an adjective neologism that denotes the opposite perspective of predictive) methods reverse the process of analysis so that the outcomes of the CAS are considered first, and then their development is traced back to determine which components and variables induced or caused change. Dörnyei proposes a three-step analysis in retrodictive qualitative modeling and uses his classroom-based research as an example. In Step 1 and Step 2, the learners in class are assigned to types that are research-relevant. He describes that researchers determine types in a collective thought experiment based on prior experience first (Step 1) and then assign individual participants to these types (Step 2; see Dörnyei, 2014, pp. 86–87). We prefer the reverse process: Based on configurations of relevant learner characteristics, we clustered participants into groups or pairs that shared a configuration of characteristics and then assigned a type to this group (for more details see below). In either case, the first two steps reduce the number of cases the researcher needs to analyze. This can be thought of as reducing the number of tokens to the number of types; the data becomes more manageable but the within-group variability is retained. At the same time, the data density for each learner type is higher than that for an individual learner.

In Step 3, Dörnyei (2014) proposes to identify "the most salient system components and the signature dynamic of each system" (p. 87). To identify the signature dynamic, the attractors and repellors of the system need to be identified and relevant developmental trajectories identified. Attractors are states of the CAS, in which the CAS finds itself frequently and often for a longer period of time. This is so because it is in such states that the CAS has reached a relative equilibrium and additional internal (e.g., motivation) or external (e.g., instruction) resources are necessary for the CAS to be able to leave this state. Because of this temporary equilibrium and an ostensible stability of attractor states, it is more fruitful for the

researcher to investigate the CAS at such a state. Repellor states, on the other hand, are states in which the CAS could find itself theoretically, but it has never been observed to enter such states. Thus repellor states limit somewhat the degrees of freedom of the CAS that the researcher would have to study. In developmental trajectories, we identify overall patterns as well as segments that occur frequently in one trajectory or across trajectories of learners of the same type and we contrast trajectories of learners of different types.

Clustering and Pairwise Comparison

As stated above, we identify research-relevant learner types by clustering study participants. We will discuss clustering using the operationalization of the collective variables for the initial conditions of the CAS in our study as an example. We applied similar procedures to the analysis of in-game variables and the perception data of the exit interviews.

We operationalized the initial conditions of the CAS as four collective variables: rationale for studying German, previous language-learning experience, gaming proficiency, and computer proficiency. For each variable, students answered a number of free-form questions on the entrance survey. Through textual analysis, we turned the verbal answers into an emerging set of categorical data. We then ranked the categories according to their potential impact on the CAS. For example, under gaming proficiency, we ranked experience with *World of Warcraft* in English higher than experience with other online games and these higher than board games. Each rank was then assigned a binary number as a value, starting with 2^0, and giving rank 2 the binary number 2^{-1}, rank 3 received 2^{-2}, and so on. Since multiple answers were possible in each category, using binary numbers allowed us to again deconstruct the sum of values unambiguously, to facilitate our qualitative analysis.[2] Having a numeric value for each variable, enabled us to conduct a clustering analysis of the complex initial conditions of our 14 participants, by computing the non-parametric correlations between all possible 91 pairs of participants (for the resulting 13 cluster pairs, see Figure 1Figure 1).

In the self-termed *pairwise comparison*, we started with the participant pair for whom we could expect greatly similar characteristics because of their high correlation values (Pair P02–P07). We conducted a retrodictive qualitative analysis for these two learners focusing on commonalities and similarities, because it was these that made them a pair. We then identified an adjacent pair (P06–P14) and conducted our comparison again, focusing mainly on similarities. In our third pairwise comparison, we focused on both pairs. We also needed to focus on the differences between pairs because these underlie their clustering in two different pairs. This analysis was then continued iteratively. Through the clustering analysis, we had reduced the number of pairs to investigate from 91 to 13. Depending on research questions and goals, the number of pairwise comparisons could be reduced further and thus made more manageable by skipping adjacent pairs that would not have yielded further new information about an individual CAS in the group. For our study, whose complete description is beyond the confines of this article, we conducted a comprehensive qualitative analysis of four pairs. Because the pairwise comparisons were preceded by an analysis of the group in its entirety and because it was based on a prior clustering analysis, identifying the most research-relevant pairs, each qualitative analysis of an individual CAS was studied comprehensively and in context of the whole group of participants.

THE STUDY: EXTRAMURAL PLAYING OF *WORLD OF WARCRAFT* IN THE SECOND LANGUAGE

With our methodology outlined, and the pertinence of examining DGBLL with a CAS theoretical framework argued, we now look to its implementation, which demonstrates the applicability of this approach to studying gaming for SLD purposes. The data came from a research study undertaken at a large Canadian university over the course of four months in the winter of 2013. Volunteers—undergraduate and graduate students from a variety of programs at the university—were asked to play the

massive multiplayer online role-playing game *World of Warcraft* in German[3] for a minimum of ten hours during their leisure time. *World of Warcraft*, like other MMORPGs, offers players a vibrant, online environment in which one can explore, meet others playing the game, and band together to accomplish challenging tasks and progress through the game (Sundqvist & Sylvén, 2012). Due to the importance placed on collaboration between players and the challenging nature of the game itself, language and communication is at the forefront of a player's experience. On-screen commands provide immediate feedback alerting the player to the efficacy and relevance of his or her actions, quests provided by computer-controlled characters instruct players to embark on extraordinary adventures with specific and often nuanced goals, and interaction between players provides strategic intervention that is often required to succeed in group tasks.

All gameplay occurred in the extramural context, removed from the presence of an instructor and the potential limitations of the classroom. Language learners were given initial instruction as to how to operate the game, but otherwise were given complete freedom to play the game when, with whom, and however they chose to play. Three times throughout the study, participants met in small groups to discuss their gameplay experiences in German. At the conclusion of the study, each learner participated in a concluding interview, reflecting on the gameplay experience and the language proficiency development that they detected. A total of 24 participants out of a larger group of volunteers elected to begin the study, and we acquired complete data sets for 14 language learners.

Our study sought to understand how a language learner's trajectory of gameplay (his or her interactions and progression in the game environment) interacts with his or her trajectory of SLD, that is, what language development emerges as a result of engaging in this experience. To do so, we looked for examples of near transfer of linguistic constructions between gaming and non-gaming contexts. If we detected evidence of a language learner having observed an unfamiliar linguistic construction while playing the game and then being able to produce it in a non-gaming context, we argue that the learner has developed further second language (L2) proficiency by playing the game in the foreign language.

The data collected reflect the learner and his or her disposition towards gameplay and language learning at the beginning (entrance survey) and end of the study (exit interview). Throughout the study, all game activity was logged and the logs were sent to the researcher after completing a session. All in-group conversations about gaming experiences were video-recorded and transcribed. Although we collected survey data pertaining to each participant's individual language learning characteristics as well as their prior experience playing games, we made no effort to hypothesize at the beginning of our study how the gameplay and SLD trajectories of these individuals would be influenced by their own learner characteristics. To do so would be to prematurely suggest certain initial conditions being influential to one's level of success. Rather, these data were only utilized to structure the pairwise comparisons to be able to focus on specific sets of learners who share (or in some cases, share very little) characteristics with one another. This was done during the cluster analysis and enabled us to identify the study participants, at whose experience we needed to look in our retrodictive qualitative modeling.

Applying Retrodictive Qualitative Modeling to DGBLL

Retrodictive qualitative modeling requires the researcher to begin at the end. To do so, we looked first to the results of this study as a means of understanding how the CAS had progressed and how gameplay and SLD had emerged over time. Only once this had been completed, we examined the initial conditions of the CAS (as well as the various stages, events, and learning opportunities that emerged through the study) in an attempt to determine which conditions may have induced change.

As we focused on pairwise comparisons, we examined a number of data points that are utilized to understand individual language-learning and gameplay experiences as best as possible. Participants were given a vocabulary test at the end of the study (see Appendix A), incorporating many of the common linguistic constructions that they would have been exposed to when playing the game. Each participant

was asked to translate a list of constructions and indicate whether or not they knew them already, or how likely it was that the construction was developed while playing the game. We then examined the responses gathered in the concluding interview, where each participant reflected on the DGBLL experience, both in terms of the gameplay itself, but also its relevance for SLD. A questionnaire (see Appendix B) was administered as well, which was adapted from Peterson (2012) and modified slightly to account for the extramural nature of this gameplay experience.

As can be observed, the two participants listed in Appendix B evidently experienced the gameplay and its effects in relation to SLD quite differently. Their results suggest that although from a gameplay perspective the experience was largely similar, its efficacy for SLD was less convincing. Making claims about a game's affordances to assist in developing L2 proficiency on the basis of these results alone, however, is misleading and masks potential variables that resulted in these divergent experiences. To determine how these trajectories of SLD and gameplay emerged, we looked to the initial conditions of the CAS and how the individuals portrayed themselves as language learners and gamers.

The Initial Conditions

Due to our reliance on retrodictive qualitative modeling, we returned to the initial conditions of this CAS to see what attributes or characteristics of the system (the game, its participants, and a myriad of other factors) had influenced the gameplay and SLD trajectories that emerged. All participants were asked to complete an entrance survey, focusing on four main areas: rationale for studying German, previous language-learning experience, gaming proficiency, and computer proficiency. Individual responses were then converted to a score as described above. Each of the four areas—collective variables that function as robust indicators of each student's initial conditions—was operationalized through multiple survey questions. The ranked scores for each answer for one initial condition were averaged for ease of processing. With each participant given a score for the four aforementioned areas, first comparisons between participants could be made (see Figure 1).

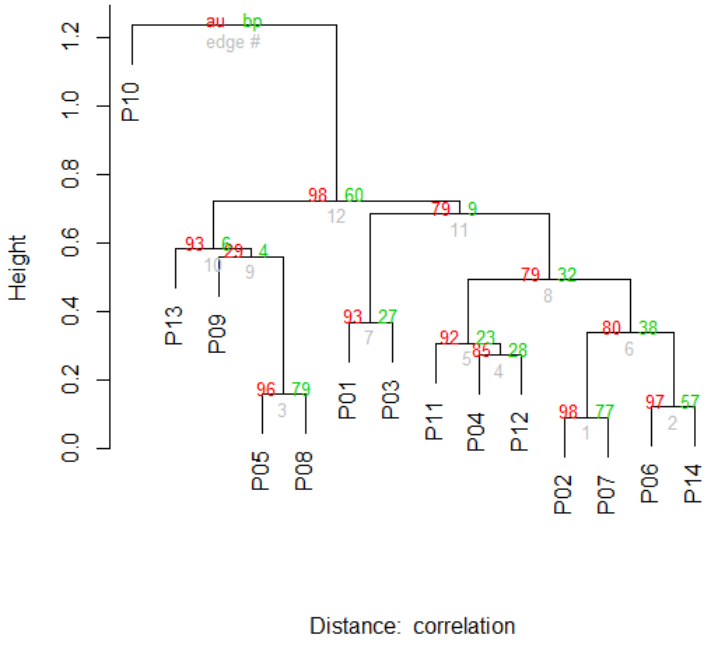

Figure 1. Dendrogram of participants' clustered initial conditions

As we mentioned earlier, CAS theoretical frameworks seek to be non-reductionist, instead examining all potential variables which may have caused change in the system. It is therefore necessary to examine not

only the learners or participants who completed the study, but also those who had initially elected to participate but, for numerous and various reasons, could not finish it. Eliminating this source of data simply masks potential variables which elicit change in the system. For this reason, we first examined the ten participants who could not finish the study (Appendix C), and then compare these to the group of 14 participants who did complete the study (Appendix D).

It is immediately evident when examining the average response of participants in both sets of data that the majority of individuals with incomplete data sets displayed less than ideal results (those falling below the mean value of all participants' responses) in two or more of the various categories encompassing the initial conditions of the CAS. Learners who are willing to invest time in extramural SLD opportunities evidently either needed to have a clear and relevant rationale for studying the foreign language or they needed to have ample previous experience learning languages in general, likely alluding to the necessary time commitment that prior language learners would be able to relate to through experience. Computer and gaming proficiency, while not as crucial, still led to better motivation and a willingness to continue playing the game and to become accustomed to it. The 14 individuals who maintained participation in the study and completed a minimum of 10 hours of gameplay over the course of four months largely had pre-existing motivation to invest time in the pursuit of learning the German language, either due to their current rationale for studying the language, or due to ample experience learning other languages. Their computer and gaming proficiency, by and large, were above the average as well.

We gained further insight into who the participants were and how similar they were to one another at the start of the study, yet we still could not make claims based upon the initial conditions alone as they may suggest different trajectories depending on how similar or divergent certain participants are to one another. Rather, these initial comparisons and analyses serve merely as a data point in the CAS, as well as a means (as was discussed previously) of conducting the pairwise comparisons which helped structure our analysis. In order to truly understand the gameplay and SLD trajectories of each participant, we needed to understand what has occurred between the end point of our analysis and the initial conditions of the CAS.

Gameplay Outcomes: Near Transfer of Linguistic Constructions

The very nature of MMORPGs such as *World of Warcraft* involved ample language production and reception through gameplay. Players of these games were exposed to huge amounts of text, whether through the quests they completed, the on-screen commands that emerged as sources of immediate feedback signifying that the player did something right or wrong, or the communication between players. All of this language was recorded automatically during the game, resulting in detailed accounts of all language encountered in the game world.

The resulting text log represented the complex nature of the CAS very well. All potential variables within the game environment that may have impacted SLD are documented and analyzable. To make sense of the wealth of text that was observed by each player, we looked to ways in which we can closely examine the language that most likely led to change and growth in SLD, and the experiences that may have most influenced their gameplay trajectories.

Two approaches assisted in comprehending this wealth of data. In the first approach, in-person conversations between participants in a group setting encouraged them to speak about their experiences in German, reflecting on which were most meaningful and engaging. Not only did these conversations provide the researcher with insight into the CAS of gaming and SLD, but they also served the crucial purpose of providing learners with a venue to share their experiences and utilize the language encountered in-game in non-gaming settings, providing evidence of their ability to transfer language between these two near contexts. The second analytical approach entails the comparative analysis of the game log texts and the conversation transcript for each learner, mainly to identify the lexical and grammatical constructions that are likely to have been developed through gameplay. To do so, we first compared the language that the learner produced out-of-game in conversational settings or as part of the vocabulary test

administered at the conclusion of the study with the language encountered and produced in-game. This resulted in a list of linguistic constructions that are found in both contexts, and helps to analyze the transcript efficiently. Afterwards, we use timestamps on each linguistic construction (in the game logs) to determine whether or not the learner had encountered it in game before using it conversationally. If so, it remained subject of our analysis, and if not, it was evident that the learner understood the construction before encountering it in-game. Finally, we utilized a list of the 1000 most frequent words in the German language (*Das Wortschatz-Lexikon*; Quasthoff & Wolff, 1999) in order to establish which constructions are infrequent enough that their development through gameplay is likely. We also compared the resulting list to a set list of linguistic constructions that the learners considered at the end of the study (see Appendix A). They were asked whether or not they believed that they emerged through gameplay factors—either as a result of experiences in-game, or conversations about the game.

These steps ensured that for each learner we had a list of all linguistic constructions that were likely developed by playing the game (for an example, see Appendix E). Although we cannot definitively state that the gameplay experience and conversations about the game led to the development of these linguistic constructions, we have ample evidence that supports these claims. These steps also align with the principles of retrodictive qualitative modeling, as we aim to understand exactly when and why certain linguistic constructions might have been developed, and how they had been further utilized both in-game and outside of game as the gameplay experience continues. How the constructions were developed was analyzed further by classifying the factors which had influenced development into three categories: gameplay (constructions which are the focus of quests or items related to progress), communication (related to the interaction between players either in or out of the game), and iteration (constructions with a very high frequency and that are used in various instances in the game).

In order to make sense of the variability between learners and the amount of language they produced throughout the study relative to the number of linguistic constructions developed through gameplay, an efficacy score was calculated. The efficacy score is represented through the following equation:

$$ES = UC/WP \times LC$$

The efficacy score (*ES*) considers the following variables: First, we take into account the number of unique constructions (*UC*) produced by the player when discussing the game in non-gaming contexts, which fall outside of the 1K frequency list range and which are likely to have been developed during the gameplay experience. Second, the number of lexical constructions produced in out-of-game situations (*WP*) is calculated to understand how often and freely the individual spoke in general in the conversation groups. Last, we take into account the total number of linguistic constructions produced outside of the 1K frequency list (*LC*), a number which includes the linguistic constructions which are understood as unique constructions, but also those which were not developed by gameplay, ultimately providing an indicator of the language learner's L2 proficiency level. The efficacy score is then calculated by dividing the number of unique constructions by the number of words produced in out-of-game situations and multiplied by the total number of linguistic constructions produced outside of the 1K frequency list. This order of operations ensures that the SLD of each learner is appropriately contextualized as a factor of all communication in the out-of-game context while simultaneously taking into account how much German was known beforehand. This score, when combined with the comprehensive list of all linguistic constructions developed through gameplay, results in a wide-ranging understanding of how each learner progressed in their individualized gameplay experiences. This level of data is necessary to know exactly when linguistic constructions have emerged and how the language learner is able to notice them and utilize them in communication or simply to discern their meaning.

Linguistically Relevant Gaming Trajectories

Finally, we analyzed the amount of language exposure each participant had while playing the game from multiple perspectives, again, to portray and understand as best as possible how exactly each learner's

trajectories of gameplay and SLD emerge. This is accomplished by examining the transcripts of each player's gameplay experiences for all instances of language exposure. We then, again relying on pairwise comparisons, depicted these trajectories graphically to demonstrate both the complexity of the experience and the general trends in terms of how learners over time became accustomed (or lost interest) in the game and, by extension, in SLD through gameplay.

By examining progress chronologically (Figure 2), on a session-by-session basis (Figure 3), and in ten-minute intervals (Figure 4), we observed precisely how and when learners were most engaged in the experience. When analyzed in conjunction with the list of linguistic constructions developed in game (Appendix E), we can argue convincingly how each learner's L2 developed as a result of gameplay in the target language.

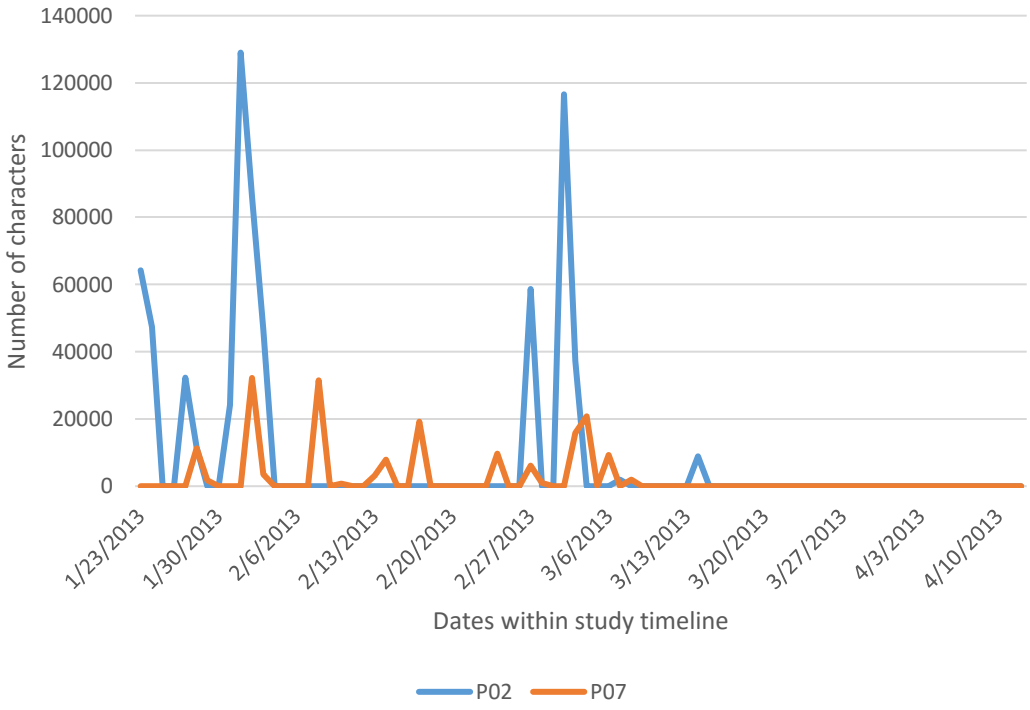

Figure 2. Chronological language exposure (P02 and P07).

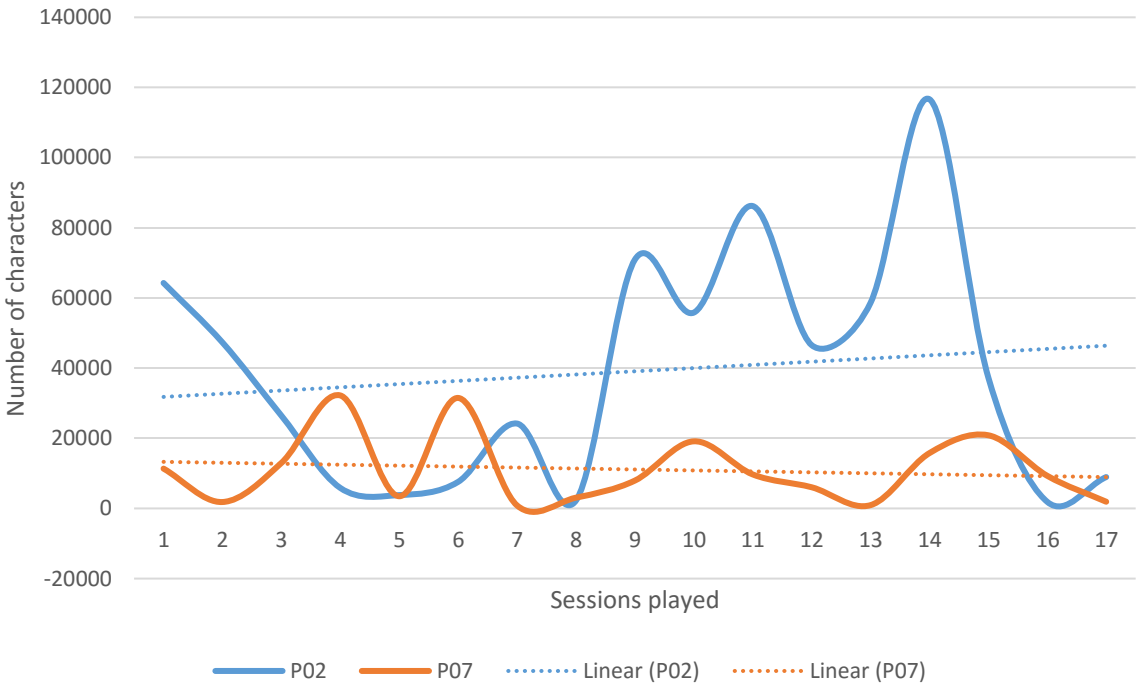

Figure 3. Exposure to language per session played (P02 and P07).

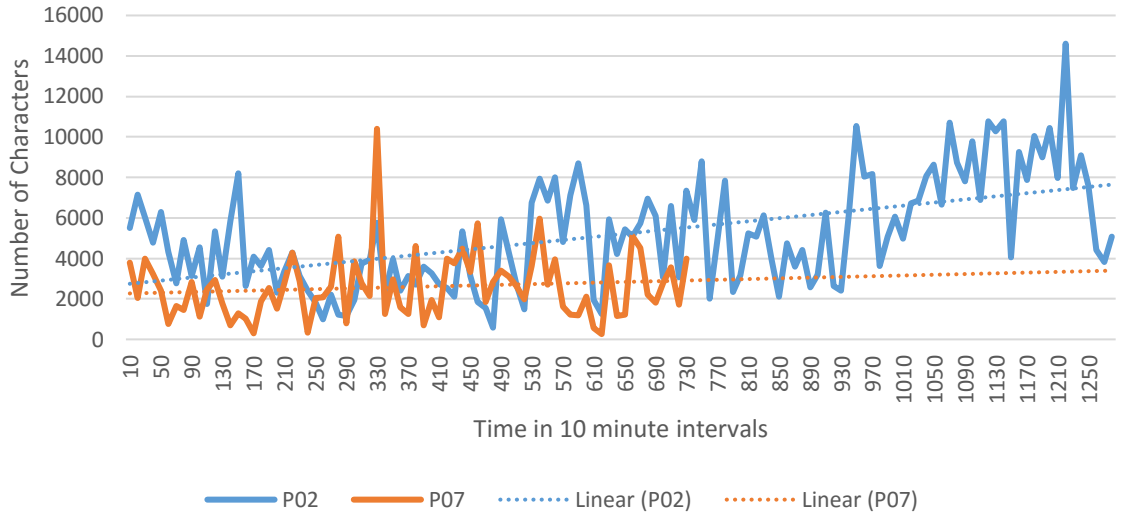

Figure 4. Exposure to language over 10-minute intervals (P02 and P07).

Each depiction of a participant's gameplay trajectory emphasizes the complexity and nonlinearity of the experience and how specific events acted as growth conditions and led to SLD. Joining guilds (groups of like-minded individuals who form a group with whom to communicate and play) led to increased opportunities for language exposure and showed a willingness to engage in conversation. Undertaking lengthy, convoluted quests could involve an initial increase in exposure to language, but due to the difficulty of the quest, a subsequent stark decline in exposure to language occurred at times, while the player was involved in scouring the game environment for clues, rather than being engaged with the

language itself.

These examples of how the gameplay trajectory can subsequently and directly impact the SLD trajectory are but initial forays into the multitude of experiences and variables that could result in change in the CAS. Relying on participant retrospection—albeit necessary—at the end of the study is not sufficient to capture the extent to which SLD occurred as a result of gameplay; rather, by adopting retrodictive qualitative modeling and analyzing empirical and exact data of the gameplay and SLD experience of each learner, we gain a thorough and comprehensive perspective of each learner's trajectories of development.

Brief Summary of Results

Our overall analysis—as illustrated above—suggests that the language observed in the gaming environment is indeed transferable to non-gaming contexts, especially when the context to which the language is being transferred is directly related to the in-game experiences of each learner, as is the case where learners will share their gameplay experiences in the L2 in non-gaming contexts. Regardless of the trajectories of gameplay in which each learner participates, SLD will occur. Factors such as time-in-game, willingness to communicate in game, reflection on in-game experiences act as (potential) growth conditions for the CAS of SLD. With the efficacy score, which indicates the overall effectiveness and quality of the gameplay experience and its implications for SLD outside of the game, we can determine to what degree the experience was impactful for the player while considering the multitude of learner and gaming-related factors that impact the process.

CONCLUSION

Due to the nature of MMORPGs such as *World of Warcraft*, and the wide variety of potential ways in which learners interact with the game, it is necessary to take an approach such as retrodictive qualitative modeling to understand digital gaming for SLD purposes as a CAS. Aspects such as the emergence of learners' L2 as they engage in the process of playing the online game, the many iterations of sub-processes in the system, and the internal and external resources that led to change in the system are all crucial components of a CAS of playing in an MMORPG like *World of Warcraft*. Examining the learners' disposition towards DGBLL at the end of the study and determining how it has evolved from the learners' initial positioning towards language learning and gameplay only serve to indicate the edges of the immense change that occurred. Considering and analyzing each learner's gameplay and SLD trajectories comprehensively and in context, however, helps to understand how and why each learner engages with the game in a unique fashion.

APPENDIX A. Word List for the Exit Vocabulary Test

Questions for each of the below item:

- Do you know this word/construction?
- What is it in English?
- In what context/where did you learn this word?
    - Learned already?
        - Maybe
        - Probably
        - Definitely
        - Already knew it but game reinforced it

Greif	Verkäuferin	bekommen
Ausdauer	Erfahrung	sterben

Stärke	Ruf	ihr habt eine neue Fähigkeit gelernt
Waffe	abgeschlossen	erhalten
Rüstung	ihr fühlt Euch normal	zur Kontaktliste hinzugefügt
Reittier	annehmen	seid gegrüßt
Beute	entdeckt	ihr müsst euch näher an diesem Ziel befinden
abbrechen	plündern	ablehnen
erstellen	zurückkehren	Belohnung
Beweglichkeit		

APPENDIX B. Concluding Interview Questionnaire (P02 & P07)

Question (Strongly Agree = 5, Strongly Disagree = 1)	**P02**	**P07**
1. The game was easy to play.	4	4
2. The chat system was easy to use	4	2
3. It was difficult to follow the quests/communication from other players	3	3
4. The quests were too difficult.	3	1
5. I actively tried to comprehend the text of the quests.	4	5
6. I experienced technical communication problems in the game.	2	2
7. There was not much feedback from other players.	4	3
8. Other players were helpful.	4	3
9. I could express my opinion more freely than in a regular class.	3	1
10. Having my own avatar made me feel more involved in the game.	4	4
11. Most of the discussion was not useful.	2	4
12. I could learn new vocabulary.	4	5
13. The game made me use my German more than in a regular class.	3	3
14. I enjoyed interacting in the game.	4	2
15. Chatting in the game was a good way to improve my German.	4	2
16. I would like to play the game again in the future.	4	2

APPENDIX C. Learner-related Characteristics and Results (Incomplete Data Sets)

	G	Age	Y	Languages	*R* (*M* = 0.42)	*L* (*M* = 0.53)	*G* (*M* = 0.63)	*C* (*M* = 0.68)
P15	F	23	4U	German; English	0.19	0.40	0.98	1.10
P16	F	19	2U	German; English; French	1.00	0.58	0.42	0.32
P17	F	20	3U	German; English; French; Spanish	0.08	1.10	0.54	0.57
P18	F	26	PhD	German; English	0.02	0.15	0.38	0.67
P19	F	37	PhD	German; English; French; Farsi	0.25	0.38	0.19	0.59
P20	M	20	2U	German; English; French	1.02	0.24	0.48	0.44
P21	F	18	1U	German; English; French; Mandarin	0.11	1.45	1.00	0.84
P22	M	23	3M	German; English; Korean; Japanese	0.02	0.44	0.79	0.43
P23	F	23	1M	German; English; Mandarin	0.02	0.37	0.16	0.20
P24	F	21	2U	German; English; French; Spanish	1.00	0.05	0.40	0.45

Notes. G = Gender; Y = Year of study; R = Rationale for studying German; L = Language learning experience; G = Gaming proficiency; C = Computer proficiency; U = Undergraduate; M = Master's

APPENDIX D. Learner-related Characteristics and Results

	G	Age	Y	Languages	*R* (*M* = 0.42)	*L* (*M* = 0.53)	*G* (*M* = 0.63)	*C* (*M* = 0.68)
P01	M	22	3U	German; English; Mandarin	1.27	0.15	0.67	1.23
P02	M	15	Grade 10	German; English	0.02	0.71	0.88	0.84
P03	M	28	6M	German; English	0.75	0.20	0.70	0.92
P04	M	37	4U	German; English; French; Spanish	0.52	0.61	0.57	0.93
P05	M	21	4U	German; English; French; Mandarin	0.50	0.65	0.93	0.71
P06	F	19	2U	German; English; French	0.13	0.76	0.94	0.86
P07	M	30	2M	German; English; French; Spanish; Italian	0.02	0.95	0.79	0.68
P08	M	23	4U	German; English; French	0.58	0.38	0.85	0.78
P09	M	24	2M	German; English; French	0.02	0.29	0.50	0.35
P10	F	26	1M	German; English; Slovak; Czech	0.02	0.70	0.56	0.34
P11	M	28	2M	German; English; French; Spanish	1.20	1.13	0.80	0.82
P12	M	20	3U	German; English; French	0.52	0.40	0.45	0.70
P13	M	25	2M	German; English; Arabic	0.25	0.25	0.27	0.54
P14	M	18	2U	German; English; French; Spanish	0.52	0.45	0.79	0.69

Notes. G = Gender; Y = Year of study; R = Rationale for studying German; L = Language learning experience; G = Gaming proficiency; C = Computer proficiency; U = Undergraduate; M = Master's

APPENDIX E. P02's Linguistic Constructions (UC = 48; LC = 178; WP = 3628; ES = 2.35)

Construction	Exposure Example	Production Example
Gameplay factors		
Ausdauer	Senku bekommt Beute: Stürmischer Umhang der **Ausdauer**.	*Vocabulary test*
Belohnung	*The reward for each quest is expressed as the Belohnung.*	*Vocabulary test*
Beute	Ihr erhaltet **Beute**: Erfrischendes Quellwasser.	*Vocabulary test*
Beweglichkeit	Beute: Waldmannsaxt der **Beweglichkeit**	*Vocabulary test*
Dungeonquests	Srfroggy hat den Erfolg "5 **Dungeonquests** abgeschlossen" errungen!	instances machen and und dann kannst du **dungeonquests** machen
Gegenstände	Eure angelegten **Gegenstände** verlieren 10% Haltbarkeit.	**gegenstände** ja uh die sind halt stärkere sachen
Greif	*Encountered frequently when riding griffons throughout the game world.*	*Vocabulary test*
heilen	Entsetzliche Monstrositäts Wunden beginnen zu **heilen.**	und uh ich kann mich dann selber heilen wenn ich zum not mich selber **heilen** muss
Hexenmeister	*Name of class played by player and constantly referred to on abilities that the player uses.*	*Vocabulary test*
ihr fühlt Euch normal	*Often repeated when having rested in an inn while taking a break.*	*Vocabulary test*
ihr habt eine neue Fähigkeit gelernt	**Ihr habt eine neue Fähigkeit erlernt**: Kochfeuerstelle.	*Vocabulary test*
ihr müsst euch näher an diesem Ziel befinden	*Pop-up message signifying the player is too far away from his or her goal.*	*Vocabulary test*
Leerwandler	Ihr habt einen neuen Zauber erlernt: **Leerwandler** beschwören.	haben sie mich mir immer gesagt meine **leerwandler** also der tank
Platte	Harukâ-Garrosh flüstert: Verstärkte Palisadenschulterstücke Polierter Helm der Ehre Brünierte Brust**platte** der Macht	ahh **platte**
plunder	**Plündern** in "Plündern als Gruppe" geändert.	*Vocabulary test*
Priesterin	König Varian Wrynn ergeht hiermit an alle tauglichen Mitglieder der Allianz der Befehl, sich umgehend bei **Priesterin** Dentaria	uh dann würde ich schon als frau **priesterin** spielen
Reittier	Ihr habt das **Reittier** Teufelsross zu Eurer Sammlung hinzugefügt.	*Vocabulary test*
Rüstung	Beute: **Rüstung** des Giftzahns	*Vocabulary test*
Schutz	Wir sollten dorthin gehen und in der Masse **Schutz** suchen.	wenn ich jetzt ein **schutz** werden
schützen	Die Armee meines Vaters im Gefängnisviertel wird sie besser **schützen** können.	Hat dieser server mehr dps **schützen** oder heiler
Wut	Die besänftigende Energie des Totems wird die Elementare langsam umspülen, bis ihre **Wut**	**wut** ja

	abgeklungen ist.	
Zwerg	Südwestlich von hier, hinter der Meistergleve, sind ein paar Ausgrabungsleiter der **Zwerge**	*Vocabulary test*
Communication factors		
Händler	Harukâ-Garrosh flüstert: beim **händler**	wo kann ich ein **Händler** finden
Heiler	[2. Handel] Ferin: Suchen noch 2 **Heiler** für RBG. Bitte nur mit Erfahrung und Gear. Für weitere Infos /w me!	und uh dann brauch ich normalerweise ein **heiler** aber ich bin ein paladin
heilt	Paladinosius-Terrordar: steht da ein !@#$%^& heal und **heilt** mich greif ich an is er weg	Warum **heilt** mir keiner :O
Instanz	[2. Handel] Leecu: Für **Instanz**enlaufen,Questen und Leveln.Raids sind später nicht ausgeschlossen.	also **instanz** war neu für mich
leveln	[2. Handel] Leecu: Für Instanzenlaufen,Questen und **Leveln.**Raids sind später nicht ausgeschlossen.	und wenn du ganz schnell **leveln** will
Levels	Nixnux flüstert: Hallo..die gilde "Sonnenanbeter"sucht nette member allen **levels**..die helfen wollen die gilde auf zu bauen	die **levels** würden immer langsamer und
moin	Pointer-Azshara: **moin**	solche neue sagen einfach mir gesagt haben also **moin** zum beispiel
seid gegrüßt	*Said in passing by NPCs*	*Vocabulary test*
Iteration factors		
abbrechen	Wenn Ihr eingeloggt bleiben möchtet, klickt auf den **Abbrechen**-Button.	*Vocabulary test*
abgeschlossen	Abgeriegelt! **abgeschlossen**.	*Vocabulary test*
ablehnen	*Found in all quest texts as a means to cancel the quest.*	*Vocabulary test*
anlagen	Wird beim **anlegen** gebunden.	Wie kann ich sachen **anlegen**?
Dungeons	Schwierigkeitsgrad des **Dungeons** wurde auf 'Normal' gesetzt.	und uh was ich schon erlebt uh meine erfahrung uh die **dungeons** sind toll
entdeckt	Militärviertel **entdeckt**: 15 Erfahrung erhalten.	*Vocabulary test*
Erfahrung	Erhaltene **Erfahrung**: 80.	und uh was ich schon erlebt uh meine **erfahrung** uh die dungeons sind toll
erhalten	**Erhalten**: 15 Kupfer.	*Vocabulary test*
Gegner	Es gefällt mir zwar nicht, dass meine **Gegner** Artillerie in die Stadt geschmuggelt haben.	und das war ganz schön uh **gegner** töten
Goblins	Ein paar **Goblins** haben es irgendwie geschafft, sich als blinde Passagiere in den Frachträumen unserer beiden Schiffe zu verstecken.	und jetzt hab ich zuletzt eine neue dungeon gemacht das war mit solche **goblins**
Klasse	[2. Handel] Shadowthorn: Die 25er Raidgilde ASCENDING sucht für Mists of Pandaria(9/16) noch Member aller **Klassen!**	**Klasse**
Quest	**Quest** angenommen: Da stimmt was nicht.	weil er hat mich gesehen wie ich immer so von quest zum **quest** gegangen bin
questen	[2. Handel] Leecu: Für Instanzenlaufen,**Questen** und Leveln.Raids sind später nicht ausgeschlossen.	also ich würde sagen ja es ist okay weil es weil nicht alle **questen** für gewalt
Quests	Die täglichen **Quests** wurden zurückgesetzt!	ich habe schon lang nicht mehr solche

		quests durchgeschafft uh
Schaden	Die Überlebenden suchen in den Ruinen Unterschlupf und fügen der Ausgrabung mehr **Schaden** zu	und uh ja also der ist mein **schaden** pro sekunde
Silber	Erhalten: 1 **Silber.**	und na ja ich hab schon das meisten **silber** also brauch ich das
Stärke	Ihr erhaltet Beute: Räuberbeinschützer der **Stärke.**	*Vocabulary test*
Stufe	Srfroggz hat den Erfolg **"Stufe** 10" errungen!	ja ich bin jetzt **stufe** zwanzig und ja

NOTES

1. The characteristics are introduced below. They are based on de Bot and Larsen-Freeman (2011). For a discussion in the context of CALL, see Schulze and Scholz (2016).
2. $2^0+2^{-1}+2^{-2}=1+0.5+0.25=1.75$ and 1.75 can only be the sum of these three numbers, if each binary number is only used once.
3. Participants went on the German registration page for *World of Warcraft*, allowing them to play on the German servers.

REFERENCES

Allen, L. K., Crossley, S. A., Snow, E. L., & McNamara, D. S. (2014). L2 writing practice: Game enjoyment as a key to engagement. *Language Learning & Technology*, *18*(2), 124–150. Retrieved from http://llt.msu.edu/issues/june2014/allenetal.html

Barnett, S. M., & Ceci, S. J. (2002). When and where do we apply what we learn? A taxonomy for far transfer. *Psychological Bulletin*, *128*(4), 612–637.

Blin, F. (2004). CALL and the development of learner autonomy: Towards an activity-theoretical perspective. *ReCALL*, *16*(2), 377–395.

Bytheway, J. (2014). In-game culture affects learners' use of vocabulary learning strategies in massively multiplayer online role-playing games. *International Journal of Computer-assisted Language Learning and Teaching*, *4*(4), 1–13.

Chapelle, C. A. (2005). Interactionist SLA theory in CALL research. In J. L. Egbert & G. M. Petrie (Eds.), *CALL research perspectives* (pp. 53–64). Mahwah, NJ: Lawrence Erlbaum.

Colpaert, J. (2013). Peripatetic consideration on research challenges in CALL. In P. Hubbard, M. Schulze, & B. Smith (Eds.), *Learner–computer interaction in language education* (pp. 272–279). San Marcos, TX: CALICO.

Cornillie, F., Clarebout, G., & Desmet, P. (2012). Between learning and playing? Exploring learners' perceptions of corrective feedback in an immersive game for English pragmatics. *ReCALL*, *24*(3), 257–278.

Das Wortschatz-Lexikon. (2001). Retrieved from http://wortschatz.uni-leipzig.de/Papers/top1000de.txt

De Bot, K., & Larsen-Freeman, D. (2011). Researching second language development from a dynamic systems theory perspective. In M. H. Verspoor, K. de Bot, & W. Lowie (Eds.), *A dynamic approach to second language development* (pp. 5–24). Amsterdam, Netherlands: John Benjamins.

Delwiche, A. (2006). Massively multiplayer online games (MMOs) in the new media classroom. *Educational Technology & Society*, *9*(3), 160–172.

Dörnyei, Z. (2014). Researching complex dynamic systems: "Retrodictive qualitative modeling" in the language classroom. *Language Teaching*, *47*(1), 80–91.

Gee, J. P. (2005). Semiotic social spaces and affinity spaces: From the age of mythology to today's schools. In D. Barton & K. Tusting (Eds.), *Beyond communities of practice: Language, power, and social context* (pp. 214–232). Cambridge, UK: Cambridge University Press.

Gee, J. P. (2008). Learning and games. In K. Salen (Ed.), *The ecology of games: Connecting youth, games, and learning* (pp. 21–40). Cambridge, MA: MIT Press.

Hubbard, P. (2009). *Computer-assisted language learning: Critical concepts in linguistics*. London, UK: Routledge.

Jakonen, T. (2014). Building bridges - How secondary school pupils bring their informal learning experiences into a content and language integrated (CLIL) classroom. *APPLES: Journal of Applied Language Studies*, *8*(1), 7–28.

Kobayashi, E., Kobayashi, M., & Fujimura, T. (2014). *A functional analysis of EFL students' discourse in the social practice of learning to play a board game*. Retrieved from https://gair.media.gunma-u.ac.jp/dspace/bitstream/10087/8827/1/2014-kobayashi.pdf

Larsen-Freeman, D. (1997). Chaos/complexity science and second language acquisition. *Applied Linguistics*, *18*(2), 141–165.

Larsen-Freeman, D. (2015). Saying what we mean: Making a case for 'language acquisition' to become 'language development'. *Language Teaching*, *48*, 491–505.

Larsen-Freeman, D., & Cameron, L. (2008a). *Complex systems and applied linguistics*. Oxford, UK: Oxford University Press.

Larsen-Freeman, D., & Cameron, L. (2008b). Research methodology on language development from a complex systems perspective. *Modern Language Journal*, *92*(2), 200–213.

Liou, H.-C. (2012). The roles of Second Life in a college computer-assisted language learning (CALL) course in Taiwan, ROC. *Computer Assisted Language Learning*, *25*(4), 365–382.

Marek, M. W., & Wu, W.-C. V. (2014). Environmental factors affecting computer assisted language learning success: A complex dynamic systems conceptual model. *Computer Assisted Language Learning*, *27*(6), 560–578.

Neville, D. O., Shelton, B. E., & McInnis, B. (2009). Cybertext redux: Using digital game-based learning to teach L2 vocabulary, reading, and culture. *Computer Assisted Language Learning*, *22*(5), 409–424.

Peterson, M. (2010). Learner participation patterns and strategy use in Second Life: An exploratory case study. *ReCALL*, *22*(3), 273–292.

Peterson, M. (2012). Language learner interaction in a massively multiplayer online role-playing game. In H. Reinders (Ed.), *Digital games in language learning and teaching* (pp. 70–92). Basingstoke, UK: Palgrave Macmillan.

Peterson, M. (2013). *Computer games and language learning*. New York, NY: Palgrave Macmillan.

Piirainen-Marsh, A., & Tainio, L. (2009). Collaborative game-play as a site for participation and situated learning of a second language. *Scandinavian Journal of Educational Research*, *53*(2), 167–183.

Prensky, M. (2001). *Digital game-based learning*. New York, NY: McGraw-Hill.

Quasthoff, U., & Wolff, C. (1999). Korpuslinguistik und große einsprachige Wörterbücher. *Linguistik Online*, *3*(2), 1–9.

Rama, P. S., Black, R. W., Van Es, E., & Warschauer, M. (2012). Affordances for second language learning in World of Warcraft. *ReCALL*, *24*(3), 322–338.

Rankin, Y., McNeal, M., Shute, M. W., & Gooch, B. (2008). User centered game design: Evaluating massive multiplayer online role playing games for second language acquisition. In *Sandbox '08: Proceedings of the 2008 ACM SIGGRAPH Symposium on Video Games* (pp. 43–49). New York, NY: ACM.

Reinders, H. (2012). Introduction. In H. Reinders (Ed.), *Digital games in language earning and teaching* (pp. 1–8). Basingstoke, UK: Palgrave Macmillan.

Reinders, H., & Wattana, S. (2012). Talk to me! Games and students' willingness to communicate. In H. Reinders (Ed.), *Digital games in language learning and teaching* (pp. 156–188). Basingstoke, UK: Palgrave Macmillan.

Schulze, M., & Scholz, K. W. (2016). Complex adaptive systems in CALL research. In C. Caws & M.-J. Hamel (Eds.), *Learner–computer interactions: New insights on CALL theories and applications* (pp. 65–88). Amsterdam, Netherlands: John Benjamins.

Smith, B. (2003). Computer-mediated negotiated interaction: An expanded model. *Modern Language Journal*, *87*, 38–58.

Sockett, G. (2013). Understanding the online informal learning of English as a complex dynamic system: An emic approach. *ReCALL*, *25*(1), 48–62.

Sockett, G., & Toffoli, D. (2012). Beyond learner autonomy: A dynamic systems view of the informal learning of English in virtual online communities. *ReCALL*, *24*(2), 138–151.

Suh, S., Kim, S. W., & Kim, N. J. (2010). Effectiveness of MMORPG-based instruction in elementary English education in Korea. *Journal of Computer Assisted Learning*, *26*(5), 370–378.

Sundqvist, P., & Sylvén, L. K. (2012). World of VocCraft: Computer games and Swedish learners' L2 English vocabulary. In H. Reinders (Ed.), *Digital games in language learning and teaching* (pp. 189–208). Basingstoke, UK: Palgrave Macmillan.

Sykes, J., & Reinhardt, J. (2012). Conceptualizing digital game-mediated L2 learning and pedagogy: Game-enhanced and game-based research and practice. In H. Reinders (Ed.), *Digital games in language learning and teaching* (pp. 32–49). Basingstoke, UK: Palgrave Macmillan.

Sykes, J., & Reinhardt, J. (2013). *Language at play: Digital games in second and foreign language teaching and learning*. New York, NY: Pearson.

Sykes, J., Ozkoz, A., & Thorne, S. L. (2008). Web 2.0, synthetic immersive environments, and mobile resources for language education. *CALICO*, *25*(3), 528–546.

Thorne, S. L. (2008). Mediating technologies and second language learning. In J. Coiro, M. Knobel, C. Lankshear, & D. J. Leu (Eds.), *Handbook of research on new literacies* (pp. 417–449). Mahwah, NJ: Lawrence Erlbaum.

Thorne, S. L., Fischer, I., & Lu, X. (2012). The semiotic ecology and linguistic complexity of an online game world. *ReCALL*, *24*(3), 279–301.

Tobias, S., & Fletcher, J. D. (2011). *Computer games and instruction*. New York, NY: State University of New York.

Tuckerman, M.E. (2008). *Reaction coordinates*. Retrieved from https://www.nyu.edu/classes/tuckerman/stat.mechII/lectures/lecture_9/node5.html

Zheng, D., Newgarden, K., & Young, M. F. (2012). Multimodal analysis of language learning in World of Warcraft play: Languaging as values-realizing. *ReCALL*, *24*(3), 339–360.

Zheng, D., Young, M. F., Wagner, M. M., & Brewer, R. A. (2009). Negotiation for action: English language learning in game-based virtual worlds. *Modern Language Journal*, *93*, 489–511.