

Motivation and Aptitude: A Partial Validation of ECT-L2A

Peter Kim¹

Teachers College, Columbia University

ABSTRACT

Energy Conservation Theory of Second Language Acquisition (ECT-L2A) (Han, Bao, & Wiita, 2017b), an interdisciplinary theory juxtaposing a physics perspective and an applied linguistics perspective, conceptualizes individuals' ultimate attainment as a function of dynamic transformation of endogenous and exogenous energies throughout the learning process. ECT-L2A predicts, *inter alia*, (1) that beginning L2 learners should show stronger motivation than end-state learners, (2) that developing learners should show higher motivation than that of beginners, and (3) that beginning, developing, and end-state learners should exhibit similar profiles in aptitude. These predictions were tested with 56 ESL learners. Correlation analyses were conducted on learners' aptitude, motivation, years of study, and performance on a timed grammaticality judgment test. The results showed that: (1) with increase in proficiency and years of study, there was a decrease in motivation; (2) the effect of aptitude diminished as learners made progress towards the target language; (3) combined effect of aptitude and motivation correlated positively with their L2 attainment, but its effects diminished as the proficiency level of the groups became more advanced.

Key words: *L2 motivation, L2 aptitude, ECT-L2A*

INTRODUCTION

One of the key objectives of Second Language Acquisition (SLA) theory synthesis is addressing the logical problem of second language acquisition (L2A) that accounts for variable and divergent outcomes in adult learners (Gregg, 2003). Identifying and accounting for individual differences (ID) that lead to variable learning outcomes has been a rich source of theoretical inquiry and empirical research. The source of divergence in L2 ultimate attainment among individual learners is multifaceted, stemming from an array of factors that make one individual different from another. Among the seemingly endless number of variables related to differential outcome, aptitude and motivation stand out as the “big two” ID factors demonstrating the most consistent correlation with L2 achievement (Ellis, 2006). Although they have both been acknowledged as being important elements that contribute to L2 learners' ultimate attainment of

¹ Peter Kim is a doctoral student in Applied Linguistics at Teachers College, Columbia University, specializing in second language acquisition. His research interests are language motivation and language aptitude in SLA. Correspondence should be sent to Peter Kim at: pk2505@tc.columbia.edu

the target language, attempts to explain both variables in one parsimonious model have been lacking, except Gardner's (2000) Social-educational model. What is missing in ID research is that, as Dewaele (2009) states, no one has yet come up with the "Grand United Theory of Individual Differences," raising doubts if a unified theory of factors mediating second language learning outcome will ever be possible (p. 625). And although motivation and aptitude have both long been established as key factors contributing to late L2 learners' differential attainment of the target language, theoretical attempts to model their role have been few and far between (Dörnyei & Skehan, 2003).

REVIEW OF LITERATURE

Among inter-learner variables, aptitude and motivation have had the strongest correlations with successful second language acquisition (Abrahamsson & Hyltenstam, 2008; Dörnyei & Skehan, 2003). The empirical basis in support of motivation and aptitude dates back to 1959, when Gardner and Lambert (1959) found that these two factors were most strongly associated with L2 achievement. Although they have both been acknowledged as important elements that contribute to L2 learners' ultimate attainment of the target language, attempts to explain the two variables in one parsimonious model have been lacking. Gardner's (2000) Socio-educational model was previously the only model that considered both aptitude and motivation in SLA. It attributes direct causes of achievement in second language acquisition to motivation and language aptitude while all other contributing factors were grouped as "other factors" (Figure 1). While Gardner's model was a novel attempt to incorporate many important variables in a single model, it did not capture the nuances of how these variables contribute to language achievement. In light of this, one method of theory synthesis that offers a promising account for diverse and disparate SLA variables and moves towards a coherent understanding of multiple factors entails looking at how natural sciences, such as physics, quantify observed phenomena through mathematical models. In recent years, Han, Bao, and Wiita's (2017a) theory of L2 ultimate attainment, known as the *Energy Conservation Theory of Second Language Acquisition* (ECT-L2A), has taken this approach by drawing on a fundamental law of physics known as the Conservation of Energy theory. The review of literature will examine the role of motivation in L2 acquisition, followed by a review of language aptitude, and conclude with a closer look at ECT-L2A.

Dörnyei's theory that highlight this drive for learning. First is the *Ideal L2 Self*, a desirable future self-image of the L2 user that the person would like to become. The second is the *Ought-to L2 Self*, which is the expectations imposed by others (e.g., family or society) that bear little resemblance to one's own ideal self. And the third is the *L2 Learning Experience*, which places the motivational impact of the learner's present learning situation, such as the instructor, peers, and the curriculum. According to this system, the three components reflect the L2 learner's perception of their identity and this perception operates in tandem with the influence of society and the environment to trigger motivation for L2 learning (Dörnyei, 2005; Dörnyei & Ushioda, 2009). A meta-analysis of L2MSS was recently reported by Al-Hoorie in 2018 based on 39 samples that totaled 32,078 language learners. In this study, the three components of L2MSS were found to be significant predictors of intended effort ($r_s=.61$), but the correlation between intended effort and achievement was weak and non-significant. Overall, motivation was a weak predictor of objective measures of achievement ($r_s=.20$) (Al-Hoorie, 2018).

In light of the meta-analysis's weak finding on motivation and achievement, it is important to note that although motivation is often assumed to lead to better results, the relationship between the two may be more complicated. For example, Binalet and Guerra's (2014) study found that motivation had no significant relationship with how participants performed on a grammaticality judgment test (GJT). As a result, the authors concluded that motivational level of the students may not be an effective predictor of success in acquisition of linguistic knowledge. Matsumoto (2011) likewise showed that motivation of L2 students was not proportional to proficiency levels of the learners. Beginners had the highest mean score for motivation while intermediate students had the lowest level of motivation. The mixed findings from the meta-analysis as well as other empirical studies regarding motivation and achievement point to a need for a fine-grained understanding of the role motivation plays in L2 development. That is, a simple linear relationship where motivation results in achievement may not be an accurate representation of a very complicated reality. In addition, motivation studies so far have examined only the singular influence of motivation on some measures of either achievement or intended effort. As Ushioda (2016) states, "...we currently have limited understanding of how motivation may interact with one or more of these other learner-internal characteristics (p. 574).

Aptitude

L2 aptitude is defined as a special talent for learning a second language that exhibits variations among learners (Dörnyei & Skehan, 2003). These variations in aptitude are believed to have neurobiological origins that engender every person's cognitive makeup to be different due to individual differences in genetics, as well as the environment (Schumann et al., 2004). Those who have higher language aptitude are assumed to reach higher level of achievement in the foreign language classroom and do so at a faster rate. While aptitude is difficult to pin down to a single definition without controversy, there are three general shared assumptions that define its characteristics. First, language aptitude is a cognitive trait as opposed to an affective (e.g., personality) or a conative (e.g., motivation) trait for learning a second language (Li, 2015, 2016; Skehan, 1998). Second, aptitude is relatively stable—an innate endowment that is fixed early in life (Skehan, 1991, 1998). And third, aptitude is not a unitary construct but a composite of different skills that interact to play a role in language learning and its ultimate attainment (Gardner & MacIntyre, 1992).

The original purpose of aptitude measure, and also the most common use to this day, is to prognosticate learners' potential for learning a second language, validated through their L2 performance. As a result, aptitude validation studies in literature have mostly focused on its predictive validity. In 2012, a review of the Modern Language Aptitude Test (MLAT) by Sasaki stated that published reports using the MLAT have found correlation at a strength of $r = 0.4$ to 0.6 , with L2 success in both classroom settings and naturalistic settings (Sasaki, 2012). A meta-analytic review of aptitude by Li (2015) looked at five decades of aptitude research and concluded that there was a moderate but robust association between aptitude and L2 grammar learning, $r = .31$. In another meta-analysis by the same author, a strong correlation was found between aptitude and L2 achievement, $r = .49$ (Li, 2016).

The construct validity of aptitude has not been explored as vigorously as its predictive counterpart, but a fairly recent meta-analytic review by Li (2016) examined correlations of aptitude with other variables related to individual differences in L2 attainment: motivation, anxiety, and intelligence. The results revealed that aptitude is distinct from motivation; has a negative correlation with anxiety; and overlaps with general intelligence but not isomorphic to aptitude (Li, 2016). Similar to the study in motivation, studies in aptitude in general have lacked a macro-level theory that encompasses not just aptitude but other important individual-difference variables, such as motivation. One macrolevel theory that encompasses both variables in a parsimonious mathematical model is ECT-L2A.

Energy Conservation Theory in Second Language Acquisition

In the field of classic physics, the principle of conservation of energy states that the total energy of an isolated system remains conserved, and energy can only be transformed or transferred from one form to another within a system. One application of this principle is the central-force problem in which an object moves toward a fixed point in circular motion without reaching the center. There are three component energies that explain this process: kinetic, potential, and centrifugal energy. If we envision the learning process as the process of being drawn to the target language, we can equally attribute learning as a process that involves transformation of energies that are kinetic, potential, and centrifugal. In physics, kinetic energy is the energy of an object due to its motion and mass. This is analogous to a learner who approaches the target language with motivation and aptitude. Potential energy is defined as the stored energy of an object due to its position relative to other objects in a system. In SLA, there is an attractive pull of the TL input that draws the learner closer to his/her ultimate attainment in the L2 acquisition process. The role played by input is theorized to act as the potential energy of the learner. Lastly, there exists a central force that draws a rotating object towards the center while the centrifugal energy provides outward force that prevents the object from reaching the center. This phenomenon is similar to a well-attested observation in SLA that adult L2 learners inevitably reach an end state of ultimate attainment characterized by asymptotic progression towards the TL without ever reaching native likeness. The repulsive barrier counteracts kinetic energy (motivation and aptitude) and potential energy (TL input traction) thus preventing the learner from completely attaining the target language is defined as the centrifugal energy. In SLA, the source of centrifugal energy is the role played by the typological distance between the TL and the L1 of the learner. The three energies from physics and their analogous counterparts are summarized in Table 1 below (Han et al., 2017a, 2017b).

TABLE 1
Operationalization of Central Force Energies in SLA

Conservation of Energy	Operationalization in SLA	Mathematical representation
Kinetic energy	Motivation	$\zeta(r)$
	Aptitude	Λ
Centrifugal energy	L1-TL typological distance	η^2/r^2
Potential energy	Traction of the TL input	$-(\rho/r)$

Mathematical modeling of the energies gives the following operationalizations and interpretations. First, aptitude is operationalized as a constant Λ , defined as an innate trait of the learner that specializes in learning an additional language other than his/her native language. Regardless of where the learner stands in the L2 developmental trajectory, the learner’s aptitude is not expected to vary but remains constant. Motivation is a function denoted as $\zeta(r)$ of the learner’s position (simply denoted as r) in the learning process relative to the target language. The domain of the learner’s position, i.e., the possible range of r is from $r=0$ to $r=\infty$, defined as the distance from the reference point of the central object, the target language. Value of $r=0$ means that the distance to the target language is zero, which is interpreted as a situation where the learner’s ultimate attainment has reached the full measure of the target language at the native-like level. When $r=\infty$ the L2 learner’s level is that of a true beginner who comes into the central force field with no knowledge of the target language, i.e., from an “infinite” distance. Relatedly, motivation $\zeta(r)$, is a function of r and it is indicative of the changes in a learner’s motivation based on his/her relative position to the target language during the learning process. The sum of two terms aptitude and motivation ($\Lambda + \zeta(r)$) is equal to the kinetic energy of the learner. The potential energy of the TL input is represented as the negative of the ratio of the “mass” of TL input (ρ) to the learner’s position in the developmental process: $-(\rho/r)$. The minus sign is to indicate that the force is attractive much like the negative sign of gravitational potential energy in physics. Finally, the centrifugal energy that serves as a barrier that prevents native-like fluency in L2 is represented as an inverse square law of the typological distance between L1 and the TL. The typological distance between L1 and TL is denoted as η and the centrifugal energy is represented as $(\eta)^2$ squared divided by the square of the learner’s developmental position r : η^2/r^2 . In L1 acquisition, $\eta = 0$ and the whole term equals zero, which eliminates the role of centrifugal energy in first language acquisition and results in learning that reaches the target language. Putting all the variables together, the conservation of energy in SLA is expressed as $\varepsilon = \zeta(r) + \Lambda + \eta^2/r^2 - \rho/r$. Given that the total energy ε is conserved for each learner in a closed system, higher ε means higher levels of ultimate attainment (Han et al., 2017a, 2017b).

When learning begins at $r=\infty$ centrifugal energy (η^2/r^2) and potential energy ($-\rho/r$) both become zero and the only terms left are $\zeta(r) + \Lambda$, meaning that for the true beginner, the only forces that propel the learner towards the TL are his/her own motivation for learning the TL and his/her aptitude. However, as the learner progresses, r decreases from ∞ and the potential energy ($-\rho/r$) begins to gain strength and play an increasing role in the language acquisition process. As the learner develops L2 competence, motivation $\zeta(r)$ increases due to the minus value of the traction provided by the input ($-\rho/r$). This is expressed as: $\zeta(r) + \Lambda - \rho/r$. Concurrently, the centrifugal energy (η^2/r^2) slowly starts to build up, until the r^2 value nears zero, which overtakes the values of all other terms and dominates the equation. At this point, due to the conservation of energy, the lone non-constant term, motivation, decreases, eventually becoming zero, and the system reaches an equilibrium of stable end-state, the ultimate attainment of the learner’s L2.

There are two equations that can be worked out for further explanation: one for the beginning when $r=\infty$ and one for when learning has reached its plateau. When $r=\infty$, $\varepsilon = \zeta(\infty) + \Lambda$ and when r approaches zero and learning becomes asymptotic, $\varepsilon = \Lambda + \eta_2/r_2 - \rho/r$. Since the total ε is conserved, the two equations can be set equal to each other: $\zeta(\infty) + \Lambda = \Lambda + \eta_2/r_2 - \rho/r$. The aptitude terms cancel each other out and algebraic rearrangement leads to the end state of ECT-L2 as the following: $\zeta(\infty) = \eta_2/r_2 - \rho/r$, in which the two r terms cease to decrease in order to match the initial energy value of motivation at $r=\infty$. The point at which the r value stops decreasing is another indication of where the learner's ultimate attainment will end up with smaller r values specifying higher attainment levels. One more rearrangement of $\zeta(\infty) = \eta_2/r_2 - \rho/r$ leads to $\zeta(\infty) + \rho/r = \eta_2/r_2$ which implies that the centrifugal energy (typological distance between L1 and TL) works against and matches the kinetic and potential energy provided by the learner's motivation plus the traction of the TL input. Simply put, no matter how much motivation one musters towards learning the TL, and no matter how much traction of the TL input pulls the learner towards the goal, the typological distance between the learner's L1 and the TL will always counteract to balance the two forces, creating an asymptotic learning plateau that never reaches the central force, the target language (Han et al., 2017a, 2017b).

In summary, ECT-L2A predicts, *inter alia*, that motivation of a true beginner with no knowledge of the TL will increase as the learner interacts with the TL input. However, as the learner advances in the L2 learning process, the typological distance between the TL and L1 prevents the learner from fully attaining the target, which leads to an asymptotic learning curve. This in turn reduces motivation to a level that is lower than his/her level as a true beginner. Aptitude, as a constant, is expected to remain the same throughout the learning process, and the combined value of motivation and aptitude is expected to decrease with increase in L2 proficiency. Based on these predictions, the following research questions were explored regarding motivation and aptitude under the ECT-L2A.

Research Questions

- 1) As learners progress towards the TL, how is motivation effected?
- 2) What is the relationship between aptitude and L2 achievement?
- 3) Do individuals with higher levels of motivation and aptitude (kinetic energy) have higher levels of L2 attainment?

METHOD

Participants

A total of fifty-six ESL students participated in the study. Participants were from the Community Language Program (CLP) at Teachers College and ESOL program at Community Impact, Columbia University. CLP participants were grouped into three proficiency levels based on institutional placement results of the language program. The placement of levels was based on a computer-based reading comprehension test, grammar test, writing test, and a 5-minute oral interview. The total score for each student was calculated based on the percentage of the number of correct responses divided by the maximum points of four tests combined. ESOL participants were placed based on an oral interview administered by the program staff. Assignment of

proficiency levels was based on the Common European Framework of Reference for Languages (CEFR) (for detailed explanation on CEFR levels, see, Little, 2006). For the purpose of this study, the cut-off score for beginner level was set at 45 percent or below (CEFR level A); for the intermediate level it was between 46 and 69 percent (CEFR level B); and the advanced level was set at 70 percent or higher (CEFR level C). This resulted in the proficiency level breakdown for the participants as 19 beginners, 24 intermediates, and 13 advanced students.

Procedure

Data collection spanned three semesters and all participants were asked to volunteer in a research study called “Motivation and Aptitude in Language Acquisition.” All participants took a brief background and motivation survey, a timed grammaticality judgement test (GJT), and completed the LLAMA aptitude test. As part of the demographic question, number of years spent on studying English was also reported. Data was analyzed using descriptive statistics, ANOVA, post-hoc Tukey, and bivariate correlation with SPSS (version 24), and R (Version 1.1.463).

Materials

Measure of Motivation

A 24-item questionnaire was designed to measure motivation according to the theoretical framework of Dörnyei’s *L2 Motivational Self System* (L2MSS). Dörnyei’s model was chosen because it is the most common theory that has dominated L2 motivation since its introduction in 2005 (Boo et al., 2015). In addition, L2MSS parallels ECT-L2A in that, instead of conceptualizing learner characteristics in a modular manner (i.e., in terms of distinct ID factors), L2MSS has a systemic approach that identifies a higher-level amalgam that acts as a whole, similar to how ECT-L2A envisions the SLA process (Dörnyei, 2009). The questionnaire itself had 24 items comprised of items that measured Ideal L2 Self, Ought-to L2 Self, L2 learning experience, and intended effort. For example, “I can imagine myself speaking English like a native speaker” gauges one’s Ideal-L2 Self; “lots of people expect me to learn English” reflects one’s Ought-to L2 Self; “I look forward to English classes” measures one’s English learning experience; and “I would like to spend a lot of time studying English” expresses one’s intended effort. The L2MSS model of motivation is validated by correlation with one’s response to intended effort. That is, if the responder shows greater level of motivation according to the L2MSS model (Ideal-L2 Self, Ought-to L2 Self, English learning experience), then it is expected that the motivation components are correlated with his/her effort intended (Shih, 2019). In the context of ESL, more highly motivated students should demonstrate more effort towards their learning goals and, consequently, there should be a positive correlation with their explicit knowledge of the grammar form. In short, high measures on L2MSS imply greater intended effort, which in turn suggests better outcome.

The items were adapted based on questionnaires by Papi’s (2010) structural equation modeling study and Islam, Lamb, and Chambers’s (2013) survey of L2MSS. Each item required the respondent to rate how the statement accurately reflected their own opinions based on a 5-point Likert scale that ranged from strongly disagree, disagree, neutral, agree, and strongly agree. For descriptive statistics, scoring of motivation was calculated by summing the Likert values for 24 items. The possible ranges were 24 to 120. For ANOVA and Pearson Correlation estimation,

the ordinal level data were converted to Rasch logits in order to transform the ordinal scale measurement to interval data scale for proper statistical analysis.

Measure of Aptitude

For the measure of foreign language aptitude, the LLAMA test was implemented for two reasons. First, most aptitude tests such as MLAT, PLAB, DLAB, CANAL-F, and Hi-LAB were designed for test-takers whose L1 is English or have instructions/interface written in English. LLAMA on the other hand is language-neutral which allows its participants to be ESL students (Meara, 2005). Second, LLAMA was based on the components of Carroll and Sapon's MLAT (Meara, 2005), which have been shown to have high predictive validity on L2 achievement (Li, 2015, 2016; Sasaki, 2012). The LLAMA₃ test is comprised of four subtests (called LLAMA_B, LLAMA_D, LLAMA_E and LLAMA_F) that measure phonetic coding ability, grammar sensitivity, rote learning ability, and inductive learning ability. LLAMA_B (Figure 2) is the vocabulary model that assess the examinees' ability to associate novel names to unfamiliar objects. Test-takers have two minutes to learn the names of 20 objects. Afterwards, their ability to recall those names is tested by matching the picture with the name. LLAMA_D (Figure 3) tests learners' ability to recognize repeated sounds in spoken language. Test-takers listen to a set of 10 words in an artificial language, and then they are tested to recognize those words from a list that includes new sounds not heard before. LLAMA_E (Figure 4) is a sound-symbol correspondence task. Examinees have two minutes to learn 24 symbols with corresponding syllable sounds. After two minutes, they are tested on their ability to correctly match the sound with the right symbol. Finally, LLAMA_F (Figure 5) is a grammar inferencing test. Examinees are given a series of pictures with a short sentence in an artificial language that describes each picture. Participants have five minutes to figure out the grammar of this unknown language. Then they are asked to match new pictures with new sentences that correctly describe them.

**FIGURE 2
LLAMA_B**

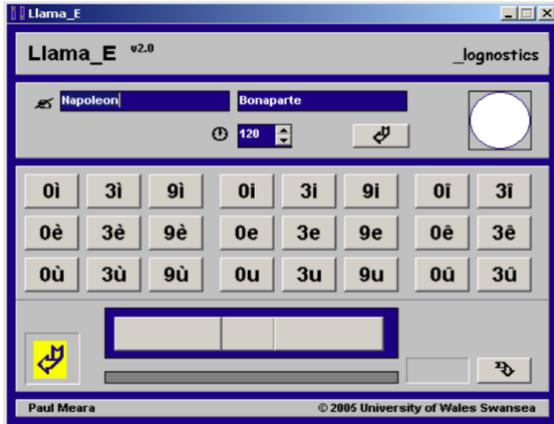


**FIGURE 3
LLAMA_D**

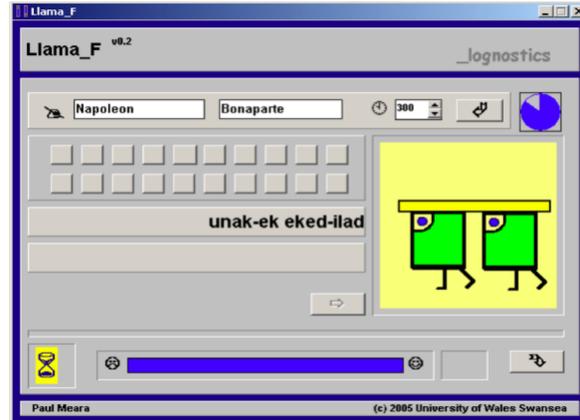


³ In the current version of the LLAMA test, there is no LLAMA_A or LLAMA_C subtests.

**FIGURE 4
 LLAMA_E**



**FIGURE 5
 LLAMA_F**



For each LLAMA subtest, percentage of items correct (number of correctly answered items/total number of items multiplied by 100) was used as the score. Four LLAMA subtests were used as the measure of each participant’s L2 aptitude. Since there are four subtests, the possible range of total scores was from 0 to 400 (Meara, 2005).

Measure of L2 Attainment

A timed grammaticality judgement test (GJT) measured the participants’ morphosyntactic knowledge of English. Timed GJT was used as a measure of automated explicit knowledge (Suzuki & DeKeyser, 2017), which is implicated in what the LLAMA_F aptitude test measures (language analytic abilities) and also what is considered the “default” method of acquisition for adult ESL learners.

The GJT used in this study was based on the one used by DeKeyser (2000) in his study “*The robustness of critical period effects in second language acquisition,*” which in turn was adopted from Johnson and Newport’s (1989) study. DeKeyser found that adults who scored high on GJT also had high verbal aptitude scores, indicating that aptitude is positively correlated to one’s performance on GJT. DeKeyser used a 200-item GJT that was an abridged adaptation of Johnson and Newport’s (1989) GJT instrument. DeKeyser reported a reliability coefficient of .91 for grammatical items and .97 for ungrammatical items on his GJT instrument. For the current study proposed here, DeKeyser’s instrument was shortened even more from a 200-item to a 156-item in order to further reduce the time spent on the measure and lessen the test-takers’ mental fatigue. The GJT comprised of 10 major categories of morphology and syntax, listed in Table 2.

**TABLE 2
 10 Rule Types Tested in Grammaticality Judgment Test**

1. Past tense	6. Yes-no questions
2. Plural	7. Wh-questions
3. Third-person singular	8. Word order
4. Present progressive	9. Particle movement
5. Determiners	10. Pronominalization

There were exactly 78 grammatical and 78 ungrammatical items. Sentences were constructed with high frequency words of one or two syllables in length, and only one violation of rule type was tested in ungrammatical/grammatical pairs. For example, past tense marking was omitted in the obligatory context:

- (1) *Sandy fill a jar with cookies last night.**
- (2) *Sandy filled a jar with cookies last night.*

The test was in paper-based format, and the participants had 30 minutes total to read each item and indicate whether the sentence was grammatical or ungrammatical. All items were randomized to ensure that they did not appear consecutively as a paired set of the same rule type. Scoring was done dichotomously with a point value of 0 for the wrong answer and 1 for the correct answer. GJT score for each participant was calculated as the total number of correctly marked items. The maximum total point possible was thus 156.

RESULTS

Relationship between Motivation and L2 Acquisition Process

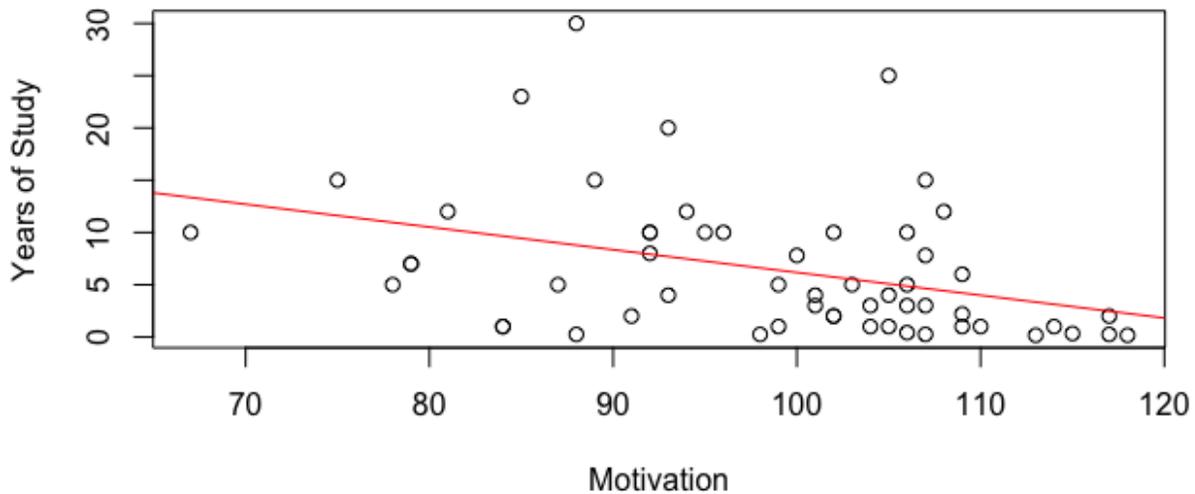
One primary question of this study involved examining changes in motivation concurrent with gains in L2 attainment per ECT-L2A. The results showed a clear but moderate relationship between motivation and timed GJT scores which was negative. Table 3 presents the comparison of mean scores and standard deviations for each proficiency group on the measure of motivation, aptitude, GJT, and years of study. Comparison of mean scores for motivation indicated that there was a steady decrease as the proficiency levels increased (Beginner > Intermediate > Advanced). The beginner group had the highest mean for total motivation score at 106.8, followed by the intermediate group at 96.7, and the advanced group with the lowest mean score of 90.2 (Table 3). One-way ANOVA on motivation showed that the differences in mean among the three groups were statistically significant ($F(2,53) = 13.117, p < .001$). Post hoc Tukey HSD analysis indicated that the motivation level of beginners was significantly different from intermediate and advanced level participants at $p=.001$ and $p=.001$ respectively.

TABLE 3
Descriptive Statistics (N = 56)

Proficiency	Motivation		Aptitude		GJT		Years studying English	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Beginner (19)	106.8	8.4	211.4	51.7	97.4	14.8	2.2	2.8
Intermediate (24)	96.7	10	231.7	43.5	116.5	15.3	7.8	6.5
Advanced (13)	90.2	11.6	272.5	42.4	118.6	15.3	10.3	8.9
Total (56)	98.63	11.65	234.3	50.9	110.5	17.6	6.4	6.9

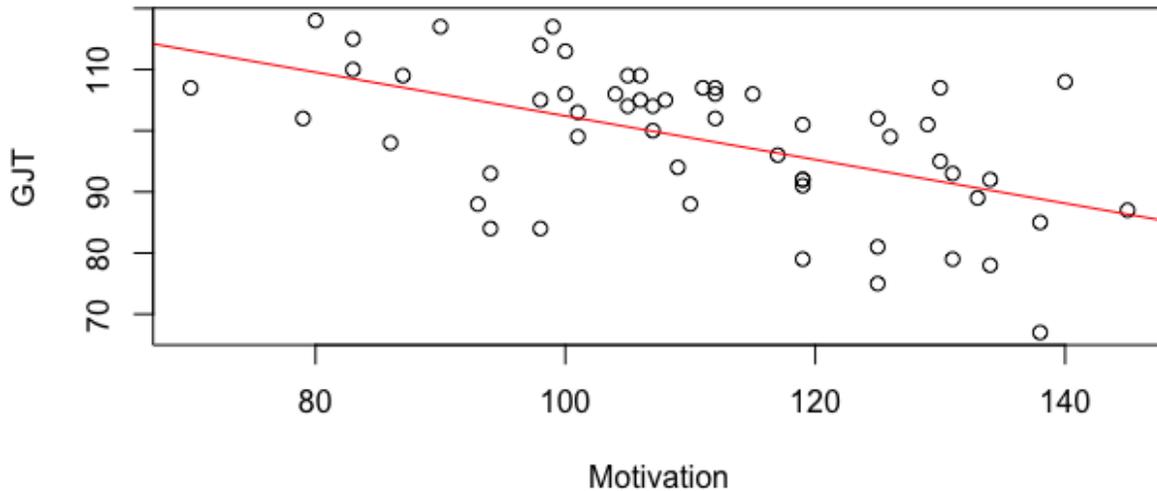
Each individual score on motivation was plotted with years of study with a regression line (Figure 6). Next, individual scores on motivation were plotted with corresponding GJT scores, also fitted with a regression line (Figure 7). Both graphs show that there was a decreasing linear relationship between motivation and years of study; and between motivation and GJT scores. The figures show that, although there is a heterogeneity of variance among individuals, a general trend of an inversely proportional relationship between the two variables is evident. Correlation between years of study and motivation was found to be $r = -.378$, $p < 0.01$ (Figure 6), and the correlation between GJT scores and motivation was $r = -.541$, $p < 0.01$ (Figure 7), with both indicating a moderate but significant relationship.

FIGURE 6
The Relationship between Years of English Instruction and Motivation to Learn English for All 56 Participants



Note. Red line indicates linear trend, $r = -.378^{**}$.

FIGURE 7
The Relationship between Total Scores on GJT and Motivation to Learn English for All 56 Participants



Note. Red line indicates linear trend, $r = -.541^{**}$.

The overall decrease in motivation was examined in detail by looking at the composite scores of Ideal L2 Self, Ought-to L2 Self, L2 experience, and intended effort in Table 4. A detailed look at the composites shows that the decrease in motivation was not due to a large drop-off in one or two categories but in all four areas of L2MSS.

TABLE 4
Descriptive Statistics for Motivation Composites (N = 56)

Proficiency	Ideal L2 Self		Ought to L2 Self		L2 Experience		Intended Effort	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Beginner (19)	26.9	3.76	24	4.66	23	2.0	32	2.9
Intermediate (24)	26.12	3.6	19	6.27	21.2	2.5	30.25	2.64
Advanced (13)	24.5	4.38	15.46	7.22	21	2.48	29	4.94

Effect of Aptitude on L2 Attainment

The second variable of interest was the role played by aptitude on L2 attainment. First, FL aptitude as measured by the sum of four LLAMA subtests exhibited a positive correlation with GJT scores for all three levels combined, $r = .435$, $p < 0.01$. One-way ANOVA on aptitude scores showed that the differences in mean among the three proficiency levels were statistically significant ($F(2,53) = 6.807$, $p < .01$). Post hoc Tukey HSD analysis indicated that the difference

in aptitude was significant between beginners and advanced students at $p=.002$. These two findings suggest that individuals with higher aptitude for learning a second language significantly outperform their peers with lower aptitude measures on the GJT, and they are also more likely to be placed in higher proficiency levels. The results support the robustness of aptitude on L2 attainment that have repeatedly found positive correlation between aptitude and L2 achievement (Li, 2015). However, the correlation between GJT scores and aptitude decreased and lost its statistical significance as the proficiency level increased from beginner to intermediate and advanced.

TABLE 5
Correlation coefficients of GJT with aptitude

Proficiency level	Average years spent studying English	Correlation between GJT and language aptitude
Beginner	2.2	.465*
Intermediate	7.8	.312
Advanced	10.3	.120

* $p < 0.05$

Beginners had the highest correlation between GJT and language aptitude at .465, $p<.05$; the intermediate group had the next highest correlation at .312, $p>.05$; and finally, the advanced group had the lowest correlation between aptitude and GJT at .120, $p>.05$. Although the effect of aptitude was shown to be positively correlated with GJT scores for all three levels as previously reported, the magnitude of the correlation decreased from .465 (moderate) to .120 (weak) as the proficiency level increased from beginner to advanced.

Combined Effect of Motivation and Aptitude on L2 Attainment

In ECT-L2A, the sum of motivation and aptitude ($\Lambda + \zeta(r)$) is defined as the kinetic energy of the learner. In quantitative data analysis, a common method of comparing variables measured on different units is to standardize their values (Cantos, 2002). Following this method, the raw scores of aptitude and motivation were converted to z-scores by subtracting each individual score from the mean and dividing by the standard deviation. Learners’ “kinetic energy” according to ECT-L2 was calculated by adding the two standard scores. When the kinetic energy of each participant was calculated this way, beginners had an average kinetic energy value of $-.2332_4$ (below the mean), intermediate learners averaged .0869 (slightly above the mean), and advanced level learners averaged the highest value above the mean at .1802. Since a learner’s kinetic energy of motivation and aptitude is equal to the total energy of the system when $r=\infty$, it can be predicted that those with higher kinetic energy will achieve high proficiency levels by the time the centrifugal energy manifests its full effect on the system. The higher kinetic values previously reported for higher proficiency levels bear some evidence that those with higher aptitude and motivation combined achieve higher proficiency. While the combined effect of motivation and aptitude is expected to positively correlate with one’s ultimate L2 attainment, according to ECT-L2A, the role of kinetic energy is expected to diminish much like the role of aptitude and motivation previously reported in the section above. This is

⁴ The minus sign does not denote ‘negative’ energy; it indicates a negative z-score.

theorized to be due to the increase in interference caused by the L1-TL typological distance that overwhelms all other forces and renders the system to reach an asymptotic state. In order to demonstrate that the combined effects of motivation and aptitude were shrinking, a regression model was fitted with motivation and aptitude as predictors of L2 achievement. The R-squared (R^2) of a regression model measures the proportion of the variance for a dependent variable that is explained by the independent variables. A reduction in R^2 is an indication of a loss of explanatory power or the effect size of a model. Table 6 presents the R^2 values on the combined effect of motivation and aptitude on GJT scores for the three groups.

TABLE 6
Regression on Motivation and Aptitude on GJT

Proficiency level	R-square values
Beginner	.259
Intermediate	.233
Advanced	.123

The role of kinetic energy (combined effect of motivation and aptitude) on GJT was the largest at .259 for the beginner group. It decreased to .233 for the intermediate group, and the lowest value was found to be at .123 for the advanced group. The results are similar to the ones found for the role of aptitude. In short, the role played by the kinetic energy of the learner on L2 attainment decreased its explanatory power as the learners progressed towards the target language.

ECT-L2A predicts that (1) beginning L2 learners should show stronger motivation than end-state learners and (2) developing learners should show higher motivation than beginning learners. The comparison of beginner proficiency level with advanced level (see Table 3) as well as the comparison of motivation and years of study (Figure 5) supports the first prediction. Beginners with a fewer number of years studying English had the highest motivation level while the advanced group with the greater number of years had lower motivation. Regarding the second statement, the question of whether developing learners have higher motivation than beginners had mixed results. The comparison of intermediate level with beginner level learners showed that beginners still had the higher level of motivation than intermediate learners. However, in ECT-L2A, the comparison of motivation is between a true beginner and a developing learner, where the traction of the L2 input increases motivation until the effect of the L1 typological distance counters it. The participants in this study were not true beginners, meaning that even for the lowest proficiency level, there was some prior knowledge of English. Still, average motivation for those who reported having studied English for one year or less was 103.35, while the average for those who reported two years was 103.75, indicating that there might be some increase in motivation with more exposure to TL input, albeit at this point the increase is fractional and not statically significant. In conclusion, examining whether the traction of input does increase motivation and at what point in the learning process would require a comparison of motivation among true beginners and those in early stages of L2 development.

DISCUSSION

In testing the predictions of ECT-L2A, this study considered the role of motivation and aptitude on L2 achievement (as measured by GJT) separately. Aptitude was shown to be positively correlated with achievement, but the effect wore off with increase in proficiency. The combined effect of motivation and aptitude also appeared to contribute positively to learning outcome. However, one surprising outcome of the correlation analysis was the strongly negative relationship found between motivation and GJT. On the surface, it appears that those who are more motivated performed worse than those who demonstrated less motivation. This result is not only counterintuitive—to think that L2 motivation would be inversely related with performance—but it also challenges the common perception that those who are more motivated will perform better on their desired learning goals (Abdul Samad et al., 2012; Gardner & Masgoret, 2003). However, as previously mentioned, other studies have shown that the relationship between motivation and achievement is not as straightforward, and the correlation may even be negative in some instances (Binalet & Guerra, 2012; Matsumoto, 2011). For example, in Johnson and Newport's (1989) seminal study on critical period effects in second language learning, partial correlation between motivation and test scores controlling for the effect of age of arrival was $-.04$, while the correlation between motivation to learn and test scores for adult learners was $.05$, though both were nonsignificant. In the current study, decrease in motivation coincided with learner's relative progression, which correlated negatively with GJT scores. Lower scores on motivation were a strong predictor of the individual's high level of L2 proficiency and, on average, advanced learners significantly demonstrated lower motivation than beginner level participants. As shown in Table 2, the mean of motivation scores decreased as the level of proficiency increased, which was statistically significant at $.001$ based on ANOVA. In addition, overall motivation was negatively correlated with years of studying English ($p < 0.01$). This counterintuitive finding on the effect of motivation is best explained by the ECT-L2 framework. The equation $\varepsilon = \zeta(r) + \Lambda + \eta_2/r_2 - \rho/r$ shows that as learning progresses, centrifugal energy (η_2/r_2) is positive, and Λ (aptitude) is constant; therefore, motivation $\zeta(r)$ decreases in order to conserve the total energy ε . As learners make progress and proficiency improves, they are met with the resistant force of the centrifugal energy, the typological distance between their L1 and the TL, which begins to decelerate their learning.

One possible cause of demotivation among more seasoned L2 learners could be that they are experiencing diminished returns on their effort towards native-like L2 competency. When learning becomes asymptotic, learners' motivation becomes tempered with realistic expectations about their ultimate attainment and along with it an awareness that further significant gains may not be possible. As Table 3 has shown, this is reflected in advanced learners' responses to all four elements of L2 motivation: their Ideal L2 Self, Ought-to L2 Self, L2 experience, and intended effort. Compared with beginner and intermediate level learners, the advanced students demonstrated the lowest level of motivation on all four composites of L2MSS (Table 4). It is important to point out that the reported decrease in motivation does not indicate that the learners were no longer motivated to learn English. Rather, it indicates mitigated enthusiasm relative to comparison groups. Based on the 5-point Likert scale scoring, a neutral response to all items would mean a total raw score of 72. All participants scored above 72 except for one advanced level participant whose raw score was 67, indicating that 55 out of 56 participants were motivated to learn English. Unlike advanced learners, beginners are not yet subject to the strong effects of

the TL-L1 typological distance and their growth is unhindered by the barrier effect of their L1. As a result, significant gains in return for their effort may be a motivating factor.

Regarding aptitude, for the entire sample (N=56) aptitude had a positive correlation ($p < 0.01$) with performance on timed GJT. Also, those with more years spent on studying English generally had higher GJT scores and higher proficiency levels. However, the wide distribution of years of study ($SD=8.9$) for advanced level learners compared with beginners (Table 3) rules out years of study as the sole explanation for higher proficiency and higher GJT scores. Advanced proficiency students had higher aptitude compared to beginners and more years studying English; however, due to the large distribution of the number of years of study, there were learners who had high aptitude and high GJT scores despite having spent a small number of years studying English. In ECT-L2, those with higher aptitude have higher kinetic energy, and the r , the relative distance from the central force, becomes smaller as the centrifugal energy increases and the total energy is conserved $\varepsilon = \zeta(r) + \Lambda + \eta_2/r_2 - \rho/r$. The ECT-L2 also predicts that, due to the increasing role of the centrifugal energy, which overwhelms all other forces, the effect of aptitude on learning decreases. This is demonstrated in the decreasing correlation between aptitude and GJT as proficiency levels increased from beginner to advanced. Correlation between aptitude and GJT for beginners was .465 and significant ($p < 0.05$), which became .312 ($p > 0.05$) for the intermediate level learners, and finally, the correlation was found to be .120 ($p > 0.05$) for the advanced level learners. According to ECT-L2, the centrifugal energy begins to dominate over other forces when the learner is near the central force. This leads to diminished returns on contributions made by aptitude in one's ultimate attainment. Although higher aptitude predicts higher GJT scores and a more advanced proficiency level, its contribution to GJT scores decreased as participants' relative position to the central force narrowed. According to ECT-L2, advanced proficiency students have r values closer to 0. One consequence of this is that the effect of centrifugal energy overwhelms the system and the effect of motivation, aptitude, and the traction of input no longer hold sway over the rate of learning, and the system reaches an asymptotic state.

CONCLUSION

To date, very few theories in SLA incorporate both motivation and aptitude to explain L2 learners' ultimate attainment. In this regard, ECT-L2 offers a promising solution as well as a new direction for future research. While the results of this study provided some promising findings, there were also limitations that hinder its generalizability. One limitation of the dataset is that it was statistically low-powered. Given the parameters of the study, a sample size of 56 achieved a power of 0.63, which is below the typical standard of 0.80 for statistical power analysis (Cohen, 1988). Moreover, because the current study was a cross-sectional study sampled from three different proficiency levels, it did not capture the transformation of the three energies during a diachronic process of L2 acquisition at the individual level. A longitudinal study on the dynamic roles played by the variables of ECT-L2 would remedy this shortcoming and significantly contribute to the validity of the ECT argument. For example, in ECT-L2A, aptitude is a constant, meaning that it does not change its value throughout the acquisition process. As Li (2016) suggests, one way to test this hypothesis is to use a combination of a between- and within-group difference study in which the same learners are tested before and after being exposed to the foreign language. Therefore, examining whether aptitude truly functions as a constant or a

variable subject to other factors requires, in part, a within-group comparison of the same learners. Finally, it is important to note that an L2 learner's motivation and aptitude only account for two of the four variables in the ECT-L2A framework. Traction of the TL, and L1 to TL distance have not been included in the study, and their role and influence on ultimate attainment, as well as their effect on aptitude and motivation, need to be verified with future empirical research.

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