Running head: The time-on-task effect in digital reading

Time-on-task effects in digital reading are non-linear and moderated by persons' skills and tasks' demands

Johannes Naumann[1] & Frank Goldhammer[2]

[1] Goethe-University Frankfurt am Main, Germany

[2] German Institute for International Educational Research (DIPF), Frankfurt am Main, and Center for International Student Assessment (ZIB), Germany

Manuscript accepted for publication in the Journal *Learning and Individual Differences*

This maunscript may not exactly replicate the final version published. It is not the copy of record.

Author note

The analysis of digital reading tasks using Coh-Metrix was funded by the German Ministry for Education and Science (Grant LSA 003, awarded to Johannes Naumann and Wolfgang Schnotz). We would like to thank the BMBF for this support. We would like to thank the OECD for making available to us the PISA 2009 Digital Reading Assessment log data, and Dr. Malte Elson (Ruhr-University Bochum, Germany) for programming the parser that read the task response times from the log files. Correspondence concerning this article should be addressed to j.naumann@em.uni-frankfurt.de

Abstract

Time-on-task effects on response accuracy in digital reading tasks were examined using PISA 2009 data (*N*=34,062, 19 countries/economies). As a baseline, task responses were explained by time on task, tasks' easiness, and persons' digital reading skill (Model 1). Model 2 added a quadratic time-on-task effect, persons' comprehension skill and tasks' navigation demands as predictors. In each country, linear and quadratic time-on-task effects were moderated by person and task characteristics. Strongly positive linear time-on-task effects were found for persons being poor digital readers (Model 1) and poor comprehenders (Model 2), which decreased with increasing skill. Positive linear time-on-task effects were found for hard tasks (Model 1) and tasks high in navigation demands (Model 2). For easy tasks and tasks low in navigation demands, the time-on-task effects were negative, or close to zero, respectively. A negative quadratic component of the time-on-task effect was more pronounced for strong comprehenders, while the linear component was weaker. Correspondingly, for tasks high in navigation demands the negative quadratic component to the time-on-task effect was weaker, and the linear component was stronger. These results are in line with a dual-processing account of digital reading that distinguishes automatic reading components from resource-demanding regulation and navigation processes.

Keywords: time on task, hypertext, navigation, digital reading, comprehension skill

Reading digital text is one key competency for participation in 21st century knowledge societies. At the same time, significant proportions of today's youths, deemed "digital natives", in fact do not master digital reading, meaning they reach only very basic levels of competency in this domain. For individual countries, these figures may be as high as 32% in OECD countries, and more than 50% in non-OECD countries (OECD, 2014). The question thus stands what precedes successful performance on digital reading tasks. One angle from which to address this issue is to ask what kind of cognitive processes are required to perform well on a digital reading task. In the following, we briefly sketch a very general approach to describe human cognitive performance, dual processing theory, and this theory's application to reading. From these perspectives we derive predictions on how time on task, as one fundamental variable in human behavior, predicts accuracy in digital reading. We test these predictions using log file data from a large scale assessment of digital reading, the PISA 2009 Digital Reading Assessment (see OECD, 2011).

1.1 Dual processing theory

Cognitive science over the last four decades has accumulated overwhelming evidence for a dichotomy between two basic kinds of cognitive processes, automatic and controlled (see Schneider & Chein, 2003, for a review). Controlled processes are slow and sequential, and interfere with each other: Typically, a person can only accommodate for a single controlled cognitive process at the same time. At the same time, controlled processes are very flexible, and can both be acquired and un-learned (in the sense that it is learned that the process must not be executed at a given point in time) in one trial. Automatic processes in contrast are fast, and become active upon encountering a well-defined configuration of mental input without the necessity of active mental control (see Schneider & Shiffrin, 1977). Automatic processes do not interfere with controlled processes, or with other automatic processes that are carried simultaneously (Schneider & Chein, 2003). At the same time, they need a consistent learning environment and a long time be learned. Consistent means that the same pattern of input in each learning trial requires the same kind of response. Controlled processes, once acquired, can thus become automatic over time. In such a learning sequence, first a production system is set up to solve a task, that is, a set of rules that "fire" and generate a specific output, once a condition is met (see Anderson, 1992; Anderson & Lebiere, 1998). Through repeated activation, these rules become more and more likely to be activated automatically.

1.2 Dual processing theory and reading

Reading is an activity that draws on both automatic and controlled processes. In skilled readers, processes such as letter and word recognition, the retrieval of word meanings from long-term memory, or the syntactic parsing of sentences will be automatic (Perfetti, 1994). However, the degree to which word and sentence level processes are automatic might vary not only in beginning, but also in adult readers. Specifically, the quality of lexical representations, meaning the degree to which context-dependent word meanings become automatically available upon encounter, varies across individuals, and is a strong predictor of comprehension (Perfetti, 2007).

Not all processes in reading are amenable to become automatic alike, especially in "task-oriented" reading situations, where a specific goal is being pursued, using multiple sources. In such situations, students need (a) to identify those parts of the text(s) that are relevant to their task. (b) They need to switch back and forth between the task and the text(s) to evaluate whether the information accumulated is sufficient to complete the task (Vidal-Abarca, Mañà, & Gil, 2010). Depending on the number, length, semantic and syntactic complexity of the text(s), and the difficulty to match the task to the text(s), these processes will require cognitive resources and are unlikely to be accomplished in a purely automatic processing mode. For example, Cerdán, Gilabert, and Vidal-Abarca (2011) had students answer questions with text, where some questions contained misleading word matches between the question and a passage of the text (i.e., the passage was in fact irrelevant to the question, but contained words that were also part of the question). In this scenario, successful comprehenders differed from unsuccessful comprehenders in that they discarded the irrelevant passages *after* they had initially considered them. While the initial attendance to the passage might well have occurred in an automatic mode, discarding it will have required controlled processing (in a fashion quite similar to identifying a letter as a distractor which previously had been learned to be a target, Shiffrin & Schneider, 1977).

Thus, in task-oriented reading scenarios that require the goal-directed selection of information, some processes will be consumptive of cognitive resources even in relatively skilled readers. This is not to say that in a *very* experienced reader, the strategies that govern decisions such as to discard initially-accessed materials as non-relevant cannot become automatic themselves (see Pressley & Afflerbach, 1995). It is however safe to say that in an average reader, a task-oriented reading situation that requires *more* decisions as to what information to access, or to discard, requires *more* controlled processing than a reading situation that requires *less* such decisions.

1.2.1 The Compensatory Encoding Model. Given that the degree of automaticity of word-level reading processes (Perfetti, 1994; 2007) impacts comprehension, the question stands how readers with less automatic reading processes at the word level might comprehend texts. Walczyk (e.g. 1995; 2000) introduced the compensatory-encoding model, claiming that readers with less automatized and thus less efficient routines at the word level might compensate for this lack of efficiency. For example, readers with less automatized word-level reading processes need to carry these processes out in a controlled mode, which burdens their working memory. As a consequence, they are less able to store incoming textual information. In line with this, Walczyk and Taylor (1996) found that readers with a low quality of meaning representations (as measured through long latencies in a semantic categorization task) had more look-backs while reading a passage. Also in line with this reasoning, Walczyk (1995) showed that the quality of meaning representations was more predictive of comprehension in a condition with time pressure than in a condition without time pressure. This result is consistent with the assumption that in the condition without time pressure, readers could compensate for lesser verbal efficiency, from which they were prevented in the time-pressure condition.

1.2.2 The time-on-task effect in reading. The considerations in sections 1.2 and 1.2.1 have implications for how time-on-task effects in reading are shaped by task and readers. From the distinction of tasks that require processes amenable to automatization to different degrees, it follows that tasks where processes *non*-amenable to automatization are prevalent will require more time to be accomplished accordingly. Readers not willing, or not able to invest this time will likely fail, meaning that in these tasks time-on-task effects will be positive. In contrast, in tasks where processes dominate that are amenable to automatization, readers with better automatized (i.e. fast and reliable) reading processes will have a better chance to succeed. Thus, in these tasks, time-on-task effects will be negative. Correspondingly, the time-on-task effect in reading will vary across person skill. Following the Compensatory Encoding Model, it should be especially lesser skilled readers that exhibit positive time-on-task effects (and vice versa): Weak readers should have a higher probability of solving a task when taking more time because of their need to compensate for lesser automatized reading processes.

A systematic investigation of time-on-task effects in reading was introduced by Goldhammer et al. (2014). Using field trial data from the OECD Programme for the International Assessment of Adult Competencies (PIAAC), these authors compared time-on-task effects in reading across tasks of varying difficulty, and readers of varying skill. They also compared these effects to those they found within the domain of “problem solving in technology-rich environments”. In accordance with the considerations above, they found strong negative time-on-task effects especially in easy reading tasks. In contrast to this, in problem solving, strong positive time-on-task effects were found for hard tasks.

Correspondingly, weak problem solvers showed strong positive time-on-task effects. In reading in contrast, the time-on-task effects became zero for unskilled readers, and was strongly negative for skilled readers.

Goldhammer and colleagues explained this set of findings in a dual processing framework. According to their reasoning, problem solving tasks are by definition resource-dependent, thus prompting strong positive time-on-task effects, in hard tasks and weak problem solvers. In contrast, the reading tasks that were used in the PIAAC assessment required only little cognitive regulation. The texts used were short, linear and of little complexity, so that automatic processes might have accounted for a large proportion of the task solution process.

1.3 Digital reading, problem solving, and navigation

Digital reading can be conceived as a domain where reading and problem solving intersect (e.g. Brand-Gruwel, Wopereis & Walraven, 2009; Rouet & Le Bigot, 2007). Specifically, digital reading tasks, when they imply information search, frequently cannot be solved on the basis of pre-existing cognitive schemas, so that a barrier exists between the given and the goal state of a readers' cognitive system (see Greiff, Kretzschmar, & Leutner, 2014; Naumann, Goldhammer, Rölke, & Stelter, 2014). This is because digital texts frequently come as hypertexts. Thus, it is left to the reader to find a task-appropriate selection of text contents (e.g. Nielsen, 1991), and a reading sequence that befits both the task and the reader's cognitive resources (see e.g. Salmerón, Cañas, Kintsch, & Fajardo, 2005). This process of selecting and sequencing text contents in hypertext reading is referred to as "navigation" (see Lawless & Schrader, 2008). Navigation is a process that relies on sub-processes that are amenable to automatization to different degrees. As pointed out in cognitive models of navigation, such as Kitajima and colleagues' CoLiDeS-Model (Comprehension-based Linked model of Deliberate Search; Kitajima, Blackmon, & Polson, 2000), or Pirolli and colleagues' SNIF-ACT (Scent-Based Navigation and Information Foraging in the ACT architecture; Pirolli & Card, 1999; Pirolli, 2005) models, a central ingredient of a navigation sequence is to match a user's goal to hyperlinks on a web page. CoLiDeS assumes four core processes, *parsing*, *focusing*, *comprehension*, and *selection* of elements on web pages. While parsing, e.g. using schematic knowledge to identify "information patches" such as a navigation bar, can be assumed to be automatic in experienced web users, other processes will need controlled processing. In particular, comprehending the contents of a hyperlink, and choosing to select it will need attentional control (Blackmon, 2012). Applying only processes highly amenable to automatization, such as using the top displayed link of a search engine results page (Salmerón, Kammerer, & García-Carrrión, 2013; Wirth, Böcking, Karnowski, & Pape, 2007), or looking for a literal (rather than a semantic) match between search goal and link will result in poor navigational choices (Salmerón, Cerdán, & Naumann, 2015). Thus, the process of navigation can be viewed as an instance of task-oriented reading (see above section 1.2), where cognitive control has to be employed when relevant texts, or paragraphs have to be selected and processed accordingly. The notion that navigation is a process that partly draws on controlled cognitive processing is also in line with evidence that working memory capacity predicts quality of navigation (Naumann, Richter, Christmann, & Groeben, 2008), and that tasks requiring more navigational choices also require more cognitive capacity (for a review see DeStefano & Levefre, 2007).

Digital reading is a complex process that besides navigation requires text comprehension (see e.g. Foltz, 1996; OECD, 2009; Rouet, 2006). This is for two reasons. First, as argued above, frequently readers need to "navigate" when reading digital text. Comprehension skills are required to decipher a hyperlink's textual label, and to make inferences as to which kind of resource clicking it will yield. A reader in possession of good comprehension skills thus will more easily comply with the navigation demands imposed by a complex digital reading task. In line with this reasoning, a number of studies have found that proficient navigation is predicted by good comprehension skills (Hahnel, Goldhammer, Naumann, & Kröhne, 2016; Naumann et al., 2008; Salmerón & García, 2011).

1.4 The time-on-task effect in digital reading

These considerations have implications for how time-on-task effects are shaped in digital reading. First of all, based on the notion that navigation typically requires controlled processing, and thus time, a positive time-on-task effect in digital reading is likely. A positive association between time on task and performance might however not hold for all persons alike. Building upon the idea that weaker readers might compensate for a lack of automatization of component reading processes through investing more time, for weak readers a strong positive association between time on task and performance might be expected. According to the above reasoning, this time-on-task effect should be diminished in strong digital readers: A skilled digital reader will have well-automatized reading processes at the word level. Also, some component processes of navigation might have become automatic. Thus, this reader will not have to compensate for lack of skill by investing more time, leading to a weaker association of time on task and performance.

A positive association between time on task and performance might not hold for all digital reading tasks alike. It is likely that especially in cognitively demanding digital reading tasks positive time-on-task effects occur. In less challenging tasks, in contrast, negative time-on-task effects can be expected. This is because in these tasks, reading processes that are prone to automatization, like word decoding, will have a greater impact on total task completion times. In psychometric terms, demanding tasks will be hard tasks, while less demanding tasks will be easy. Following this line of reasoning, in hard digital reading tasks, time-on-task effects will be strongly positive. In contrast, in easy digital reading tasks, the time-on-task effect will be diminished, and reversed to negative eventually.

Finally, time-on-task effects in digital reading need not be assumed to be linear. The idea that it is the need for controlled processing that triggers positive time-on-task effects also implies that once these requirements have been met, investing additional time will not further increase the probability of correctly solving a task. This consideration is also in line with recent results on the time-on-task effect in complex problem solving (Greiff, Niepel, Scherer, & Martin, 2016).

1.4.1 The moderating role of comprehension skills. As noted above in section 1.2.1, readers who have poorly automatized reading processes and thus are weak comprehenders might compensate by investing additional time. Thus, in weak comprehenders, a strong positive linear component to the time-on-task effect can be expected. Strong comprehenders in contrast should achieve a high probability of solving a digital reading task already at intermediate levels of time on task. However, even strong comprehenders might fail on a digital reading task if they invest too little time. Likewise, in strong comprehenders taking very much time, the probability of task success might drop off again: Since strong comprehenders should not need much time to complete a digital reading task, very long completion times will probably mean distraction or noticing to be on the wrong track.

1.4.2 The moderating role of navigation demands. Although one typical feature of digital text is that it has to be “navigated” by the reader, not all digital tasks pose navigation demands to the same degree. As pointed out above in section 1.3, the mental load put on a reader by a hypertext environment is dependent on the number of navigational choices required. Thus, especially tasks that require a large number of navigational choices should require a controlled processing mode, and thus trigger positive time-on-task effects. Navigation demands are but one candidate amongst others to moderate time-on-task effects in digital reading. For example, text length and syntactical complexity might moderate time-on-task effects through in addition to navigation demands. In the present research however we started off with navigation demands as one key feature of digital texts which sets them apart from typical printed text (see e.g. Afflerbach & Cho, 2008), and which has been prominently described in the literature as making the processing of digital text specifically dependent on cognitive resources (DeStefano & LeFevre, 2007). However, even in tasks with low navigation demands, extremely short response times might be detrimental to task success. Even in these tasks, some time will be required to adequately process the task assignment, and match it to the text at hand. Thus, while in low navigation demands tasks, long response times indicate inefficiency, and quick (below-average) response times might indicate efficiency, response times at the lower end of the distribution might indicate carelessness. Thus, in these tasks, we expected an inversely u-shaped form of the time-on-task effect. In contrast to this, in high navigation demands task, quick response times will be detrimental, and additional time on task will increase probability of task success. Due to the cognitive effort required by these tasks, however, the time-on-task effect can be expected to stay positive across the whole range of the time on task distribution, being steeper toward the lower, and flatter toward the higher end.

1.4.3 Combined role of comprehension skill and navigation demands. If it were true that especially weak comprehenders benefit from more time on task, and that more time on task has to be spent especially in high navigation demands tasks, it follows that performance should deteriorate especially in weak readers investing little time in high navigation demands tasks. Weak readers investing little time in low navigation demands tasks should suffer less in their performance by comparison.

1.5 The present research

Time-on-task effects in digital reading have not yet been systematically investigated. Thus, a first goal of the present research was to investigate how in digital reading time-on-task effects would be shaped by person skill and task difficulty. A second goal was to explain how time on task would be shaped by each one crucial predictor of digital reading performance on the person side (comprehension skill), and on the task side (navigation demands). A third goal was to explore whether time on task-effects would be non-linear, other than in Goldhammer et al. (2014), where only linear time-on-task effects had been considered.

From the above discussion of processing demands and time-on-task effects in digital reading we derived the following hypotheses:

Hypothesis 1: Across persons and tasks, time on task and performance in digital reading are positively associated.

Hypothesis 2: Time-on-task effects in digital reading are strongly positive in weak digital readers, and weaker in strong digital readers. There is thus a negative correlation between digital reading skill and person-specific time-on-task effects.

Hypothesis 3: Time-on-task effects in digital reading are positive in hard tasks, but negative in easy tasks. There is thus a negative correlation between task easiness and task-specific time-on-task effects.

Hypothesis 4: The time-on-task effect in digital reading is moderated by a negative quadratic trend. This trend is such that across persons and tasks, the regression of performance on time on task is steeper towards the lower end of the time on task distribution and levels out towards the higher end.

Hypothesis 5: The linear component of the time-on-task effect is moderated by comprehension skills, meaning a stronger linear component in weak readers, and a weaker linear component in strong comprehenders.

Hypothesis 6: The quadratic component to the time-on-task effect is moderated by comprehension skill, meaning a stronger (more negative) quadratic component in strong, and a weaker (less negative) quadratic component in weak comprehenders.

Hypothesis 7: The linear component to the time-on-task effect is moderated by navigation demands, meaning a positive linear component to the time-on-task effect in high navigation demands tasks, and a negative linear component in low navigation demands tasks.

Hypothesis 8: The quadratic component to the time-on-task effect is moderated by navigation demands, meaning a stronger (more negative) quadratic component in low, and a weaker (less negative) quadratic component in high navigation demands tasks.

Hypothesis 9: The interaction between time on task and navigation demands is stronger in weaker comprehenders as opposed to stronger comprehenders. There is thus a negative three-way interaction between time on task, comprehension skill and navigation demands.

2 Method

2.1 Participants

We analyzed data from 19 countries and economies that participated in the PISA 2009 digital reading assessment. The PISA study (OECD, 2014) aims at evaluating educational systems worldwide by monitoring students' preparedness for applying their knowledge in real-life situations. PISA regularly assesses reading, mathematics and science, and related context variables. In PISA 2009 reading was the major domain, and the paper-and-pencil reading assessment was complemented by the Digital Reading Assessment as an international option. We included those students of the PISA 2009 Digital Reading Assessment for whom complete and valid log files were available (N = 34,062, see Table 1 for sample descriptives). Drop-out due to non-availability of log files was low, and amounted to 1.4% (or 500 cases).

2.2 Materials and measured variables

For the present study, the students' digital reading performance was measured, and the probability of success in a digital reading task was the to-be-explained variable. As explanatory variables the students' time on a digital reading task, their comprehension skill, and the task's navigational demands were assessed.

2.2.1 Digital reading performance. Digital reading performance was measured by 29 tasks (items) administered in the PISA 2009 Digital Reading Assessment through coded responses (credit = 1, no credit = 0). Where tasks had partial credit (8 tasks), both full and partial credit were coded 1. The proportion of correct responses (either full of partial credit) per task and country is given in Table 2. The 29 tasks were distributed across nine units. The tasks involved reading scenarios and texts that were typical for digital reading at the time the tasks were developed (April-November 2007). The units were allocated in three 20-minute clusters, with two clusters building a test form to be completed by a student. Each cluster was combined with one of the other clusters, once in the first position and once in the second position, resulting in a design balancing the position and pairing of clusters.

The tasks varied in the degree to which they required navigation. This is illustrated by the tasks of two published sample units. In task 3 of the unit “Sports Club”, students needed to read an E-Mail exchange between two girls, Liz and Anna, who talk about joining a sports club (see Figure 1a). Students are asked to match Liz and Anna’s requirements (e.g. price, opening hours) with information that is accessible from four sports clubs’ websites through links embedded in the E-mail exchange. This task poses high navigation demands, as students need to access the sports clubs’ websites, and in these find the relevant information. In between, they need to revert to the E-mail exchange, as only from there the sports clubs’ sites are accessible. This task requires 10 steps of navigation.

In the unit “Language Learning” students are supposedly using a website called LanguageLearning.com, where a number of language learning related services are offered, such as finding a partner for exchange lessons. In task 3, students find in their messages an E-mail from a dubious “Salesman”, who offers a “VocabTrainer”, and are tasked with judging whether they should take up his offer (see Figure 1b). This task poses low navigation demands, as students are prompted directly with the “messages” page within the “LanguageLearning.com” website, and thus no navigation is required. In 42% of the tasks, navigation was guided by explicit directions as to which pages should be opened, or looked at. See OECD (2011) for detailed information about the Digital Reading Assessment.

2.2.2 Time on task. Time on task was measured from the onset of a task until a person gave a response. Time on task thus comprised reading the directions, engagement with the stimulus, possibly completion of the navigation sequence required, processing of text, and giving a response. To account for the skewness of the response time distribution, the original time on task, which was measured in milliseconds, was log-transformed, and finally grand-mean centered across all countries.

2.2.3 Comprehension skill. Comprehension skill was measured through the PISA 2009 print reading assessment. This assessment covers access and retrieval, integration and interpretation, and reflection and evaluation of textual information, as well as processing continuous texts and non-continuous texts (e.g. a newspaper article that is accompanied by a graph or a table). Comprehension skill was scaled according to the Rasch model, establishing a common scale for person skill and item difficulty and thus allowing to compare ability estimates of students who received different sets of items due to PISA's rotated booklet design. This common scale could be created through random assignment of students to booklets and the use of common item clusters across booklets. Weighted least squares estimates (WLEs) were used. Comprehension skill was grand-mean centered across all countries. The WLE reliability was .80 (OECD, 2012, p. 194).The correlation between comprehension skill and digital reading performance was .83 (OECD, 2011). See OECD (2009) for further information on the PISA print reading assessment framework.

2.2.3 Navigation demands. Navigation demands were measured by counting the number of navigational steps needed to complete a task. These comprised visiting pages that were accessed for navigation and pages that had content to be processed (see OECD, 2011, ch. 3). The number of required navigational steps per task was counted by one of the authors and a graduate student research assistant. The only two inconsistencies, each of which amounted to one navigational step, were resolved through discussion. Across all 29 tasks in the assessment, the mean number of required steps was 2.9 (*SD* = 1.4). The number of required steps was grand-mean centered across items.

2.3 Procedure

Data collection was administered by the respective national test centers, and overseen by the international PISA consortium (see OECD, 2012, for details). Students were tested during school hours. First the paper-pencil based part of the assessment was administered. This comprised the print reading, as well as the PISA mathematics and science assessment, and lasted for two hours. Students could take a break after one hour. Upon completion of the paper-pencil assessment and after another break, the digital reading assessment was administered. This assessment lasted for 40 minutes in total. This global time limit was generous such that the test was not supposed to be speeded. This was supported by the very small average number of not-reached tasks per booklet of below .40 out of 18 or 19 (see OECD, 2012, Chapter 12). The digital reading tasks were presented in a secure environment where a browser was simulated that mimicked features of current Web browsers such as Opera, Chrome, Firefox, or Internet Explorer (see Figures 1a and 1b). Before the actual assessment students completed a 10-minute tutorial that made them familiar with the features of the test environment, and the simulated browser's navigation devices such as links or tabs.

2.4 Statistical analysis

2.4.1 Modeling approach. The Generalized Linear Mixed Model (GLMM) framework (e.g. De Boeck et al., 2011; Doran, Bates, Bliese, & Dowling, 2007) was employed. In the present study, the linear model includes as dependent variable the logit of the probability of person p for solving task i (log-transformed odds), ln[p/(1-p)], and a linear combination of predictors explaining the logit. Mixed effects model means that it contains both fixed effects which are constant across units of a population (e.g., tasks, persons, class rooms), and random effects which may vary across units of a population. In the present study, the basic GLMM represents an item-response theory (IRT) model with random persons and random items, or tasks (De Boeck, 2008), which accounts for items or tasks being nested within units through an additional random unit effect:

$$\ln[p/(1-p)] = \beta_0 + b_{0p} + b_{0t} + b_{0u} \quad (1)$$

In this model, β_0 is a fixed effect (intercept) representing the logit that is expected for an average person completing an average task in an average unit, b_{0p} is a random effect representing the by-person adjustment to the intercept (person parameter, i.e., skill), b_{0t} is a random effect representing the by-task adjustment to the intercept (task parameter, i.e., task easiness), and b_{0u} is a random effect representing the by-unit adjustment to the intercept (unit parameter, i.e., unit easiness). The distributions of the random effects across persons, tasks, and units respectively are modeled as multivariate normal distributions, $\mathbf{b_p} \sim N(\mathbf{0}, \mathbf{\Sigma_p})$, $\mathbf{b_t} \sim N(\mathbf{0}, \mathbf{\Sigma_t})$, and $\mathbf{b_u} \sim N(\mathbf{0}, \mathbf{\Sigma_u})$ with $\mathbf{0}$ as vectors including the mean values fixed to be zero, and $\mathbf{\Sigma}$ as the respective estimated covariance matrices of the random effects.

Note that in (1) the by-task adjustment to the intercept b_{0t} represents task easiness, whereas in IRT models the polarity is typically inverse making the task parameter to represent the task's difficulty. Regardless of the parameterization, the parameter explains response variability due to task differences. Similarly, the by-person adjustment to the intercept accounts for response variability due to person differences and is typically labeled as person skill. Although it is common practice in IRT to model the influence of tasks as fixed effects, we model random effects for both theoretical and practical reasons. In line with the population argument (cf. De Boeck, 2008), digital reading tasks are developed based on a framework (see OECD, 2009) specifying multiple design features (texts, cognitive processes, situations). Such features delineate a population of possible tasks. Each generation of a task by a task writer considering these features can be thought of as a draw from this population. Thus, the set of systematically developed tasks can be conceived as a sample from a population of tasks being representative for the to-be-assessed construct. From a practical point of view, random task effects allow to estimate random effect correlations and related statistical inference.

To test the assumption that the time-on-task effect varies across tasks and persons the basic model was extended by the predictor time on task with a fixed effect component and random effect components across tasks and persons (cf. Goldhammer et al., 2014). Finally, to test the assumption on the moderating roles of the tasks' navigation demands and the persons' comprehension skill, they were included as predictors interacting with time on task. By adding these predictor variables to (1) the meaning of b_{0p} (person skill) and b_{0t} (task easiness) is somewhat changed in that they now explain response variability that is not accounted for by the included predictor variables. The extended models that were used to test the hypotheses are described at the beginning of the respective results section. For estimating the GLMMs, the glmer function of the package lme4 version 1.1-7 (Bates, Maechler, Bolker, & Walker, 2014) was used in the R environment (R Core Team, 2015). For comparing nested GLMMs, the likelihood ratio (LR) test providing a χ^2 statistic was used (e.g., Bolker et al., 2009).

2.4.2 Aggregating fixed effects. To aggregate fixed effects (time on task in Model 1, time on task, navigation demands, and comprehension skill, and their interactions with time on task in Model 2) across countries, we employed a random-effects meta-analytic model (Hedges & Vevea, 1998), with country-wise analyses serving as “studies”. In this model, the overall effect is decomposed into three components: First, a grand total effect that is the same in all studies (here: countries), and second a study-specific effect due to methods or materials, or persons that do not come from the same population. Random-effects meta-analysis treats this effect as being random, and estimates its variance τ^2. The third component is a random effect of sampling variance. For the present research, random-effects meta-analysis lends itself for two reasons. First, we can come up with a figure that represents the effect of interest (e.g. the overall time on task-effect) across countries that is independent of country-specific effects. Second, between-country variability of effects is explicitly taken into account, and separated from sampling variance, and can thus be tested for significance. As a measure of heterogeneity we report the standard deviation of the study-specific effects τ, and test τ^2 for significance using Cochran’s Q statistic (see Hedges & Olkin, 1985). Meta-analyses were conducted using the R package *metafor* (Viechtbauer, 2010).

2.5 Ruling out potential confoundings

All in all, testing hypotheses 2 and 5-9 already implied a model with a total of 12 fixed effects. Thus, rather than estimating an overly complex model including a large number of controls and possible interactions as additional fixed effects, we checked in advance whether potentially confounding variables on the person and task levels would be substantially correlated with the predictors comprehension skill and number of required steps. If this were not the case, this would rule out these variables as confounders in advance.

2.5.1 Persons. Besides comprehension skill, a number of other person-level variables might moderate the time-on-task effect in digital reading. Specifically, it might be inexperienced computer users, who need to take more time to successfully complete a digital reading task. To rule out this possibility, we looked at the correlations of comprehension skill with self-confidence in high level ICT tasks, online reading frequency, ICT use at school, use of ICT for school related tasks at home and ICT and internet use for entertainment at home. As can be seen from Table 3, these five correlations were low, neither of their median values across all participating countries and economies exceeded .21, and neither of their maxima exceeded .36. It is thus unlikely that any potential effects of comprehension skill are due to a confounding with computer experience.

2.5.2 Tasks. To rule out a confounding of the task-level variable navigation demands (i.e., number of required steps) with text length, or text difficulty, we computed for each task the number of words contained within the pages relevant for the task, the mean word frequency, the mean word length in syllables, and the Flesch reading ease. These four variables were computed using Coh-Metrix (McNamara, Graesser, McCarthy & Cai, 2014; McNamara, Louwerse, Cai, & Graesser, 2013). Note that we computed these variables based on the international (English) version of the digital reading assessment so that the correlation results presented in the following only hold for this version. Furthermore, to rule out a confounding with navigation demands other than the number of required steps, we computed the point-biserial correlation between the number of required steps and explicit navigation guidance provided by a task (by explicit directions as to which pages should be visited). As can be seen from Table 3, the correlations of these five variables with the number of required steps were low, and neither of their absolute values exceeded .32. It is thus unlikely that any potential effects of the number of required steps will be due to a confounding with text length, text difficulty, or navigation guidance.

3 Results

We set up two models to test the above hypotheses. Model 1 aimed at estimating the time-on-task effect in digital reading (hypothesis 1), varying across persons (hypothesis 2) and tasks (hypothesis 3), as specified in Goldhammer et al. (2014) for reading and problem solving. Model 2 aimed at extending model 1 through inclusion of non-linear time-on-task effects, and fixed effects of comprehension skill and navigation demands, and their interaction with time on task (hypotheses 4-9).

3.1 Linear time-on-task effects and time-on-task effects across persons and tasks

We tested the linear time-on-task effect and the assumption that the time-on-task effect varies across tasks and persons, and that the by-task and by-person time-on-task effects covary with tasks' easiness and persons' skill by estimating the following model:

$$\ln[p/(1-p)] = \beta_0 + (\beta_1 + b_{1p} + b_{1t})\,(\text{time on task}) + b_{0p} + b_{0t} + b_{0u} \qquad (2)$$

In this model, β_1 is the fixed linear effect of time on task. b_{1p} is the by-person adjustment to the fixed time-on-task effect, and is modeled as a random variable. b_{1t} is the by-task adjustment to the fixed time-on-task effect and is modeled as a random variable.

3.1.1 Linear time-on-task effect. Overall, the fixed effect of time on task was positive and significant in each country, with the only exception of Korea (see Table 4, column 3). Meta-analytically this effect was significant, $\beta = 0.35$ ($SE = 0.03$), $z = 11.11$, $p < .05$. This means that averaged across persons and tasks, longer response times were associated with better odds of succeeding on a digital reading task. This effect was associated with significant between-country variance, $\tau = 0.09$, $Q(18) = 31.54$. These results give support to hypothesis 1.

3.1.2 Time-on-task effects across persons. Random time-on-task effects across persons were inspected to see whether variance in time-on-task effects across persons could be explained by skill level as suggested by hypothesis 2. In two countries the variance of the time-on-task effect across persons, and the covariance of the time-on-task effect across persons with the random person intercept could not be estimated independently from one another, as indicated by a correlation of 1 and -1 respectively. Random time-on-task effects across persons were not interpreted for these two countries.

3.1.2.1 Does the time-on-task effect vary across persons? A condition for explaining time-on-task effects across persons through skill levels is that the time-on-task effect varies across persons. To test this assumption, we restricted Model 1 by excluding all random time-on-task effects across persons, and then added the variance of random time-on-task effects across persons, b_{1p}, while still restricting the covariance between b_{0p} and b_{1p} to be zero. Comparing these two models indicated a significantly better fit of the more liberal model allowing the variance of b_{1p} to be non-zero in 13 countries and economies (see Table 4, columns 6-7).

3.1.2.2 Is the time-on-task effect by person explained by skill levels? To address the assumption that the time-on-task effect in digital reading does not only vary across persons, but is associated with a persons' skill level, we first inspected the correlation between skill level and the by-person adjusted time-on-task effect. For 17 countries and economies, there was a negative correlation between persons' skill and the by-person adjusted time-on-task effect (see Table 4, column 8, and Figure 2, top row for an illustration). To test these correlations for significance we forced the covariance between the random time-on-task effect across persons and the by-person adjustment to the intercept to be zero. This restriction caused a significant decrease of model fit in each country and economy with the exception of Austria (see Table 4, column 9). Thus, consistently across 16 countries and economies, there was a positive time-on-task effect for persons with comparatively low skill levels. With increasing skill level, this positive time-on-task effect was diminished. At the same time, in neither country with the only exception of Korea, negative time-on-task effects were observed for skilled students. These results give strong support to hypothesis 2.

3.1.3 Random Time-on-task effects across tasks. Random time-on-task effects across tasks were inspected to see whether variation in time-on-task effects across tasks could be explained by task easiness as suggested by hypothesis 3.

3.1.3.1 Does the time-on-task effect vary across tasks? A condition for explaining time-on-task effects across tasks through task easiness is that the time-on-task effect varies across tasks. To test this assumption, we restricted Model 1 by excluding all random time-on-task effects across tasks, and then added the variance of random time-on-task effects across tasks, b_{1t}, while still restricting the covariance between b_{0t} and b_{1t} to be zero. Comparing these models indicated a significantly better fit of the more liberal model, allowing the variance of b_{1t} to be non-zero, in all countries and economies (see Table 4, columns 10-11). Thus, consistently across all countries and economies, the association of time on task and task performance varied across tasks.

3.1.3.2 Is the time on task by task effect explained by task easiness? In hypothesis 3 we assumed that the time-on-task effect by task would covary with task easiness. To test this assumption, we first inspected the correlations between task easiness and the by-task adjusted time-on-task effect. As can be seen from see Table 4 (column 12) in each country and economy, a negative association between task easiness and the by-task adjusted time-on-task effect was found (see Figure 2, bottom row for an Illustration). To test these correlations for significance, we restricted Model 1 by forcing the covariance between the random task effect and the random effect of time on task across tasks to be zero. This restriction resulted in a significant decrease of model fit for all countries and economies with the only exception of Poland (see Table 4, column 13). Thus, in 18 countries and economies, the strength of the time-on-task effect was negatively associated with task easiness. Strong positive time-on-task effects were observed in hard tasks. These effects decreased with increasing task easiness and were reversed to negative in easy tasks, giving strong support to hypothesis 3 (see Figure 2, bottom row, for an example).

3.2 Non-linear time-on-task effects, moderated by comprehension skill and navigation demands

We tested the assumed non-linear time-on-task effect and the moderating effects of comprehension skill and navigation demands to both the linear and quadratic component of the time-on-task effect by including additional fixed predictors in Model 2. The following model was estimated:

$$\begin{aligned}
\ln[p/(1-p)] = {} & \beta_0 + (\beta_1 + b_{1p} + b_{1t}) (\text{time on task}) + \beta_2(\text{time on task}^2) + \beta_3(\text{time on task}^3) \\
& \beta_4(\text{comprehension skill}) + \beta_5(\text{time on task} \times \text{comprehension skill}) + \\
& \beta_6(\text{time on task}^2 \times \text{comprehension skill}) + \\
& \beta_7(\text{navigation demands}) + \beta_8(\text{time on task} \times \text{navigation demands}) + \\
& \beta_9(\text{time on task}^2 \times \text{navigation demands}) + \\
& \beta_{10}(\text{comprehension skill} \times \text{navigation demands}) + \\
& \beta_{11}(\text{time on task} \times \text{comprehension skill} \times \text{navigation demands}) + \\
& \beta_{12}(\text{time on task}^2 \times \text{comprehension skill} \times \text{navigation demands}) + b_{0p} + b_{0t} + b_{0u} \qquad (3)
\end{aligned}$$

Additional model parameters, as compared to Model 1, are the following: β_2 is a fixed nonlinear (quadratic) effect of time on task. β_3 is a fixed nonlinear (cubic) effect of time on task.[1] β_4 is the fixed effect of a person's comprehension skill, measured through the PISA print reading assessment. β_5 is the fixed effect of the interaction between time on task and

[1] This parameter was introduced for control purposes. In a model without this parameter, any interaction of quadratic time on task with either comprehension skill or navigation demands might have been spurious. We would like to thank an anonymous reviewer for this suggestion.

comprehension skill. β_6 is the fixed effect of the interaction between quadratic time on task and comprehension skill. β_7 is the fixed effect of a task's navigation demands, measured through the number of required steps. β_8 is the fixed effect of the interaction between time on task and navigation demands. β_9 is the fixed effect of the interaction between quadratic time on task and navigation demands. β_{10} is the fixed effect of the interaction between comprehension skill and navigation demands. β_{11} is the fixed effect of the three-way interaction between time on task, comprehension skill and navigation demands. β_{12} is the fixed effect of the three-way interaction between quadratic time on task, comprehension skill and navigation demands. Model 2 was set up to test hypotheses that correspond to fixed effects only. Only these fixed effects of relevant predictors are described in the following in detail. Random effects are available upon request from the first author.

3.2.1 Linear time-on-task effect. The fixed linear time-on-task effects per country were similar to those obtained in Model 1, and were once again significant in each country with the only exception of Korea (see Table 5, column 3). The meta-analytically derived effect was $\beta = 0.30$ ($SE = 0.03$), $z = 11.43$, $p < .05$. Other than in model 1, the fixed time-on-task effect showed no between-country variation over and above sampling variance, $\tau = 0.01$, $Q(18) = 19.03$, $p > .05$.

3.2.2 Quadratic time-on-task effect. The fixed quadratic time-on-task effect was negative and significant in each country with the only exception of Colombia (see Table 5, column 4). This meant that, in accordance with our assumptions, the odds of succeeding on a task at first increased with time on task. With increasing time on task however this effect eventually waved off (see the bold line in Figure 3a). The meta-analytically derived quadratic time-on-task effect was $\beta = -0.15$ ($SE = 0.01$), $z = -12.47$, $p < .05$. This effect was associated with significant between-country variation, $\tau = 0.05$, $Q(18) = 99.83$, $p < .05$. These results give support to hypothesis 4.

3.2.3 Effect of comprehension skill. The fixed effect of comprehension skill was positive and significant in each country (see Table 5, column 6). The meta-analytically derived effect was $\beta = 0.80$ (*SE* = 0.02), *z* = 33.08, $p < .005$. This effect was associated with significant between-country variation, $\tau = 0.10$, Q(18) = 276.51, $p < .05$.

3.2.4 Interaction of comprehension skill with linear time on task. The interaction between comprehension skill and the linear component of the time on task was significant and in the expected direction in each country, with the only exception of Colombia (Table 5, column 7). The negative sign of the regression coefficient meant that the positive time-on-task effect was decreased in strong comprehenders, while it was increased in weak comprehenders. The meta-analytically derived effect was $\beta = -0.07$ (*SE* = 0.01), *z* = -5.84, $p < .05$. This effect was associated with significant between-country variation, $\tau = 0.05$, Q(18) = 81.84, $p < .05$.

To interpret the interaction between comprehension skill and linear time on task, we conducted simple slopes analyses (see Aiken & West, 1991). We estimated the linear time-on-task effect conditional on comprehension skill of one standard deviation below, and above the mean. For weak comprehenders, these analyses yielded a strong positive linear effect of time on task in 18 countries (see Table **7**, column 2 and the left-hand white boxplot in Figure 3b). Meta-analytically the linear time-on-task effect at comprehension skill of one standard deviation below the mean was $\beta = 0.36$ (*SE* = 0.03), z = 13.71, $p < .05$. This slope was not associated with significant between-country variation, $\tau < 0.01$, Q(18) = 11.71, $p > .05$. For strong comprehenders, positive linear time-on-task effects were reduced in most countries, but remained significant in 11. In eight countries, there was no significant effect of time on task for strong comprehenders (see Table 7, column 3, and the left-hand grey boxplot in Figure 3b). Meta-analytically, the effect of time on task in strong comprehenders was $\beta = 0.23$ (*SE* = 0.04), z = 6.04, $p < .05$. This slope was associated with significant between-country variation, $\tau = 0.11$, Q(18) = 34.32, $p < .05$. Overall, these results give support to hypothesis 5, which had assumed that the linear time-on-task effect would be decreased with increasing comprehension skill.

3.2.5 Interaction of comprehension skill with quadratic time on task. The quadratic effect of time on task was moderated by comprehension skill in the expected direction in ten countries (see Table 5, column **7**). This meant that the time-on-task effect was more linear in weak as opposed to strong readers. Meta-analytically this interaction was negative as well, $\beta = -0.02$ ($SE = 0.01$), $z = -3.41$, $p < .05$, and it was associated with significant between-country variation, $\tau = 0.01$, $Q(18) = 55.81$, $p < .05$. To further interpret this interaction we estimated the quadratic time-on-task effect conditionally on comprehension skill. For weak comprehenders, the overall quadratic trend was reduced, although it was still substantial and significant in each country except for Colombia (see Table 7, column 4, and the right-hand white boxplot in Figure 3b). Meta-analytically, an effect of $\beta = -0.14$ ($SE = 0.01$), $z = -11.00$, $p < .05$ was observed, which had significant between-country variation, $\tau = 0.05$, $Q(18) = 114.48$, $p < .05$. In strong comprehenders, in contrast, a stronger quadratic trend to the time-on-task effect was observed. The meta-analytical effect was -0.17 ($SE = 0.01$), $z = -11.94$, $p < .05$ (see Table 7, column 5, and the right-hand grey boxplot in Figure 3b). This effect had significant between-country-variation, $\tau = 0.05$, $Q(18) = 79.34$, $p < .05$. These results give support to hypothesis 6.

3.2.6 Effect of navigation demands. The fixed effect of navigation demands was negative in each country, but significant in none. Meta-analytically a significant negative effect emerged, $\beta = -0.13$ ($SE = 0.05$), $z = -2.36$, $p < .05$. This effect was not associated with significant between-country variation, $\tau < .01$, $Q(18) = 3.84$, $p > .05$.

3.2.7 Interaction of navigation demands with linear time on task. The interaction between navigation demands and the linear component of the time on task was in the expected direction and significant in 18 countries (see Table 6, column 3). The positive sign of the interaction effect meant that the linear time-on-task effect was increased in tasks with higher navigation demands, while it was decreased in tasks with lower navigation demands. The meta-analytically derived effect for the interaction was $\beta = 0.28$ ($SE = 0.02$), $z = 11.38$, $p < .05$. There was no significant between-country variation, $\tau < .01$, $Q(18) = 7.70$, $p > .05$.

To further interpret this interaction we conducted simple slopes analyses. We estimated the linear time-on-task effect conditional on navigation demands of one standard deviation above, and below the mean. In low navigation demands tasks, the expected negative linear time-on-task effect was found in only one country (see Table 7, column 6 and the left-hand white boxplot in Figure 3c). In all other countries, the time-on-task effect was not significant in low navigation demands tasks. Meta-analytically the effect was not significant, $\beta = 0.02$ (SE = 0.04), $z = 0.41$, $p > .05$, and not associated with significant between-country variation, $\tau = 0.04$, $Q(18) = 18.31$, $p > .05$.

In contrast, for high navigation demands tasks, there was a strong positive time-on-task effect in each country as expected (see Table 7, column 7, and the left-hand grey boxplot in Figure 3c). Meta-analytically, this slope was significant, $\beta = 0.58$ ($SE = 0.03$), $z = 16.12$, $p < .05$, and not associated with significant between-country variation, $\tau < .01$, $Q(18) = 9.34$, $p > .05$. Overall, these results give partial support to hypothesis 7, which had assumed that the time-on-task effect would be moderated by navigation demands, and that strongly positive linear time-on-task effects would be obtained for high navigation demands tasks, while negative linear time-on-task effects would be obtained for low navigation demands tasks. While the time-on-task effect was moderated by navigation demands in the expected direction, negative time-on-task effects occurred in low navigation demands tasks in just one country.

3.2.8 Interaction of navigation demands with quadratic time on task. The quadratic time-on-task effect was moderated by navigation demands as expected in six countries (see Table 6, column 4). This meant that in these six countries the quadratic time-on-task effect was stronger (more negative) in tasks posing low, as opposed to tasks posing high navigation demands (see the right-hand panel of Figure 3c). Meta-analytically this interaction was positive, $\beta = 0.03$ ($SE = 0.01$), z = 3.34, $p < .05$, and associated with significant between-country variation, $\tau = 0.03$, $Q(18) = 51.49$, $p < .05$. The quadratic time-on-task effect was especially strong in low navigation demands tasks (see Table **7**, column 8, and the right-hand white boxplot in Figure 3c), $\beta = -0.18$ ($SE = 0.02$), $z = -10.92$, $p < .05$. This effect varied across countries, $\tau = 0.06$, $Q(18) = 98.10$, $p < .05$. In high navigation demands tasks in contrast, the time-on-task effect was slightly more linear (see Table **7**, column 9, and the right-hand grey boxplot in Figure 3c), the meta-analytical effect for the quadratic term was $\beta = -0.13$ ($SE = 0.01$), $z = -9.46$, $p < .05$, and associated with significant between-country variation, $\tau = 0.05$ $Q(18) = 52.04$, $p < .05$. These results give support to hypothesis 8.

3.2.9 Three-way interaction of time on task with comprehension skill and navigation demands. The expected two-way interaction between comprehension skill, navigation demands, and (linear and quadratic) time on task was found in neither country. For linear time on task the interaction was positive in all countries with the only exception of Chile (see Table 6, column 6), whereas for quadratic time on task it was negative in seven countries (see Table 6, column 7). Thus, other than expected in hypothesis 9, overall the interaction between comprehension skill and time on task was weaker in tasks posing high navigation demands than in tasks posing low navigation demands. Figure 3a helps to understand how this unexpected finding emerged. In low navigation demands tasks, strong comprehenders, who invested little time, achieved a good performance as well, while poor comprehenders who invested little time achieved less than poor comprehenders who invested more time. In high navigation demands tasks, in contrast, time on task mattered also for strong comprehenders. In these tasks, both strong and weak comprehenders achieved more when they took more time.

4 Discussion

The present research analyzed effects of time on task on accuracy in digital reading, conditional on properties of persons and tasks. We discuss the results of this investigation regarding their relations to previously found patterns of time-on-task effects in reading and problem solving, to dual processing theory, and to the concept of navigation in digital reading. Concluding, we discuss the present research as to its implications for assessment, its limitations, and possible avenues of future research.

4.1 Time-on-task effects across domains, dual processing, and navigation

The present pattern of time-on-task effects is compatible with the notion that digital reading is a domain where reading and problem solving intersect, and relies on automatic and controlled modes of processing to different degrees, conditional on person and task characteristics. As found by Goldhammer and colleagues (2014) for reading and problem solving, we found time-on-task effects varying both across persons and tasks. As to persons, Goldhammer et al. had found negative time-on-task effects in reading, that were more negative for more skilled persons. In problem solving, in contrast, time-on-task effects were positive, and the more positive the less skilled persons were. The present results for digital reading resemble much more this latter pattern, despite the domains being clearly different (e.g. the PIAAC assessment requiring persons to use tools such as spreadsheets, thus invoking skills not targeted in the digital reading assessment). This is in line with the notion that digital reading, as problem solving, draws on cognitive resources. It is also in line with the notion that persons with lesser ability will have to mobilize more cognitive resources to achieve as much as more able persons. This is supported by the finding that time on task matters the more for digital reading performance, the lower a persons’ comprehension skill.

As to tasks, once again the present pattern of time-on-task effects resemble more those found in Goldhammer et al. (2014) for problem solving than those found for reading. In their research, time-on-task effects in reading ranged from zero to negative. In the present research however, time-on-task effects were positive, rather than zero, for hard tasks, and negative only for tasks at the lower end of the task difficulty distribution. These results are compatible with a view that cognitive processes required for the reading of easy, and linear, texts (as those used in the PIAAC assessment) are amenable to automatization to a large degree. In digital reading in contrast, navigation is a process that frequently will go wrong when completed in an automatic processing mode (e.g. Salmerón et al., 2015). This is true at least when the evaluation of different parts of the text as to their utility in the present task is required, as it was the case in the Digital Reading Assessment.

This is however certainly not to say that navigation is the only variable that invokes a need for controlled processing in digital reading. Consider for example the task displayed in Figure 1b. This task poses no navigation demands. It is, nevertheless, relatively hard, due to demands other than navigation. For example, it requires students to use multiple features of the salesman's message to determine it can't be trusted, its bad language as well as the fact that the salesman is not on the user's "friends" list. While in some instances evaluative judgments of text are fast and automatic (Richter, Schroeder, & Wöhrmann, 2009), in others they are not. This is e.g. the case when multiple sources and cues need to be integrated (see Britt, Richter, & Rouet, 2014, for an integrative discussion). In these instances, evaluative judgments become effortful (e.g. Metzger & Flanagin, 2013). These considerations might explain why we did not find negative associations between time on task and performance in low navigation demands tasks (with the only exception of Korea).

Similar considerations apply to the person level. The present research identified comprehensions skill as one manifest variable that moderated time time-on-task effects. In doing so, the present analysis made an important step beyond the Goldhammer et al. (2014)

research, where no attempts were made to specify which cognitive variables apart from skill in the targeted domain might explain the variation of the time-on-task effect across persons. This is of course not to say that comprehension skill is the only variable contributing to persons' aptitudes in digital reading to the effect that time on task-effects are moderated. For example, Goldhammer, Naumann, and Keßel (2013) found that speed in basic computer tasks, such as clicking a hyperlink, had a substantial positive correlation with digital reading performance. One interpretation of this result is that persons with well-automatized ICT skills have more cognitive capacity available to comply with the cognitive demands posed by digital reading. If this interpretation were true, not only comprehension skills, but also ICT skills would moderate the time-on-task effect in digital reading. Using PISA data unfortunately we weren't able to address this question, as ICT skills are not assessed in PISA.

Extending previous research, the present study investigated the quadratic effect of time on task and its interaction with person and task characteristics. The negative interaction effect suggests that with increasing time the meaning of time on task is changed from a factor of success to one of failure, especially in highly skilled persons and/or easy tasks. Interestingly, the interaction of quadratic time with person and task characteristics was exactly in line with the dual-processing account, that is, for weak comprehenders and tasks with high navigation demands the time-on-task effect was more linear. The quadratic component may be regarded a general property of how time on task is related to task success (which had been missed in previous research), and it is the combination of person and task characteristics that determine which linear and/or curvilinear components constitute the effect. For instance, for a task completed in the automatic mode, an inversely u-shaped function with an immediate and rapid increase followed by a gradual decrease in the probability of success could be expected (i.e., mostly a negative effect), while for a task completed in the controlled mode, a gradual increase and then a late and only small decrease could be assumed (i.e., mostly a positive effect).

4.2 Implications for assessment

Time on task in basic reading tasks such as decoding is regularly used for assessment (see e.g. Richter, Naumann, Isberner, & Neeb, in press). With the advance of computer-based assessment also of text-level reading skills, it appears natural to ask whether time on task might serve as an indicator of competence here as well. As suggested by the present results, researchers and practitioners should advance with caution. As the present results indicate, time on task has very different associations with performance depending on features of both tasks and persons. Possibly, this is the case because time on task reflects different processes, depending on properties of tasks and persons. Thus, much more research will be needed to identify components of the task-completion process in digital reading tasks that can be unequivocally tied to cognitive processes (see e.g. Goldhammer et al., 2014, and Zoanetti, 2010, who analyzed time on task components in problem solving tasks). Also, research will have to investigate how the present effects of time on task, which were obtained with a rather lenient time limit, will generalize to reading tasks with strict per-item time limits (see e.g. Goldhammer & Kröhne, 2014), or tasks without time limit, but the instruction to work as fast as possible (e.g. Richter et al., in press, Richter, Isberner, Naumann, & Neeb, 2013).

4.3 Limitations and directions

One of the obvious strengths of the data set analyzed in this research is that it provides large samples, and cross-country and cross-culture comparability of results. We were surprised how closely many of the effects analyzed in the present research generalized across countries and educational systems. It is worth noting however that while most of the effects found in our study proved to be rather consistent, a number of effects could be identified in some, but not in other countries. This is e.g. true of the interaction between the quadratic time-on-task effect and comprehension skills. This effect was significant and in the expected direction in 11 out of 19 countries and economies. In one country though it was substantial in the direction opposite to our hypothesis, namely Korea. Interestingly, this country stands out in a number of ways in our analysis, for example, it is the only country with no significant fixed time-on-task effect, and is the only country where person-specific time-on-task effects become negative for very skilled readers (see Figure 2). One explanation for this set of findings could be that Korea was by a substantial margin the top-performing country in the PISA 2009 Digital Reading Assessment. In other words, good Korean students (relative to their within-country peers) might master cognitive requirements in an automatic cognitive mode, where good students in other countries (relative to their within-country peers) have to engage in a controlled mode. With the number of countries that participated in the Digital Reading Assessment having grown to 32 in PISA 2012, it will be worthwhile to in more depth analyze potential between-country variation of the effects that in this study displayed heterogeneity in effect sizes.

One obvious major weakness of large scale data as a basis for substantive research though is that they are frequently correlational, as in the present case. Put differently, there are other possible explanations for the present set of results beyond a dual-processing account. For example, weak digital readers, as well as weak comprehenders, might not have compensated for their lack of skill by devoting additional cognitive resources to the task after all. Rather, they might just have quickly chosen a random answer when they realized the task was beyond their skill level. Experimental accounts will thus be needed that actively control time on task and available cognitive resources, or aim at generalizing the present results to situations without a clear time limit, such as search on the real Internet.

Another weakness of large scale databases for research of course is their restriction on the variables available in the dataset. Beyond comprehension skill, a number of other person-level variables might moderate the time-on-task effect in digital reading, which were not available to the present research. It is for example possible that the time-on-task effect in digital reading is moderated not only by comprehension, but also by navigation skills. A person in possession of highly accessible knowledge about the structure of a website, and good routines in making navigational choices might be less in need of additional processing time in digital reading than a less skilled navigator. Once again, future research will have to seek out this issue, as in the present dataset we had no measure available of navigation, or ICT skill as a variable on the person level.

Finally, in the present research, we had only a limited number of tasks available. While this number was large enough to model tasks as a random effect, and thus allow for generalizability of our results beyond the exact tasks used in the assessment, it was not large enough to accommodate a comprehensive set of fixed task level effects, such as the dimensions specified in the PISA reading framework. For example, it might well be the case that digital reading tasks that according to the framework require students to “reflect and evaluate” information are not only harder, but also produce stronger positive time-on-task effects than tasks that require students to “access or retrieve” information (see OECD, 2009, for details). Thus, what modeling of task difficulty as a random effect tells us is that harder tasks that are constructed according to the PISA reading framework produce more positive time-on-task effects. We also know that this finding is reliable for *any* set of tasks that was constructed according to this framework (which we had not known if we had modeled task difficulty as a fixed effect). What we do not know however is which exact task features beyond navigation demands drive this effect.

We also do not know if there are undetected confounds of navigation demands with other task-level variables. Although we could rule out such confounds for a number of variables on the person as well as the task side, once again, experimental accounts will be informative where task demands are controlled by the researcher in a balanced design.

References

Afflerbach, P., & Cho, B.-Y. (2008). Identifying and describing constructively responsive comprehension strategies in new and traditional forms of reading. In S.E. Israel, & G.G. Duffy (Eds.), *Handbook of research on reading comprehension* (pp. 69-90). New York: Routledge.

Aiken, L. S. & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. Newbury Park, CA: Sage.

Anderson, J. R. (1992). Automaticity and the ACT* theory. *American Journal of Psychology, 105*, 165–180. DOI:10.2307/1423026

Anderson, J. R. & Lebiere, C. (1998). The Atomic Components of Thought. Mahwah, NJ: Lawrence Erlbaum Associates.

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2014). *lme4: Linear mixed-effects models using Eigen and S4*. R package version 1.1-7, http://CRAN.R-project.org/package=lme4.

Blackmon, M. H. (2012). Information scent determines attention allocation and link selection among multiple information patches on a webpage. *Behaviour & Information Technology, 31*, 1-15. DOI: 10.1080/0144929X.2011.599041

Bolker, B. M., Brooks, M. E., Clark, C. J., Geange, S. W., Poulsen, J. R., Stevens, M. H. H., White, J.-S. S. (2009). Generalized linear mixed models: a practical guide for ecology and evolution. *Trends in Ecology & Evolution, 24*, 127-135. DOI: 10.1016/j.tree.2008.10.008.

Brand-Gruwel, S., Wopereis, I., & Walraven, A. (2009). A descriptive model of Information Problem Solving while using Internet. *Computers & Education, 53*, 1207-1217, DOI: 10.1016/j.compedu.2009.06.004

Britt, M.A., Richter, T., & Rouet, J.-F. (2014). Scientific Literacy: The role of goal-directed reading and evaluation in understanding scientific information. *Educational Psychologist, 49*, 104-122. DOI: 10.1080/00461520.2014.916217

Cerdán, R., Gilabert, R., & Vidal-Abarca, E. (2011). Selecting information to answer questions. Strategic individual differences when searching texts. *Learning and Individual Differences, 21,* 201-205. DOI: 10.1016/j.lindif.2010.11.007

De Boeck, P. (2008). Random item IRT models. *Psychometrika, 73,* 533-559. DOI: 10.1007/S11336-008-9092-X

De Boeck, P., Bakker, M., Zwitser, R., Nivard, M., Hofman, A., Tuerlinckx, F., & Partchev, I. (2011). The estimation of item response models with the lmer function from the lme4 package in R. *Journal of Statistical Software, 39,* 1-28.

DeStefano, D., & LeFevre, J.-A. (2007). Cognitive load in hypertext reading: A review. *Computers in Human Behavior, 23*, 1616-1641, DOI: 10.1016/j.chb.2005.08.012

Foltz, P. W. (1996). Comprehension, coherence, and strategies in hypertext and linear text. In J. Levonen, J. F. Rouet, A. Dillon, & R. Spiro (Eds.), *Hypertext and Cognition*. Mahwah, NJ: Lawrence Erlbaum.

Goldhammer, F., & Kroehne, U. (2014). Controlling Individuals' Time Spent on Task in Speeded Performance Measures: Experimental Time Limits, Posterior Time Limits, and Response Time Modeling. *Applied Psychological Measurement*, *38*, 255-267. DOI: 10.1177/0146621613517164

Goldhammer, F., Naumann, J., Keßel, (2013). Assessing individual differences in basic computer skills: Psychometric characteristics of an interactive performance measure. *European Journal of Psychological Assessment, 29,* 263-275. DOI: 10.1027/1015-5759/a000153

Goldhammer, F., Naumann, J., Stelter, A., Tóth, K., Rölke, H., Klieme, E. (2014). The time-on-task effect in reading and problem solving is moderated by task difficulty and skill: Insights from a computer-based large-scale assessment. *Journal of Educational Psychology, 106*, 608-626, DOI: 10.1037/a0034716

Greiff, S., Kretzschmar, A., & Leutner, D. (2014). Problemlösen in der Pädagogischen Psychologie [Problem solving in Educational Psychology]. *Zeitschrift für Pädagogische Psychologie, 28*, 161-166.

Greiff, S., Niepel, C., Scherer, R., & Martin, R. (2016). Understanding students' performance in a computer-based assessment of complex problem solving. An analysis of behavioral data from computer-generated log files. *Computers in Human Behavior, 61*, 36-46. DOI: 10.1016/j.chb.2016.02.095

Hahnel, C., Goldhammer, F., Naumann, J., & Kröhne, U. (2016). Effects of linear reading, basic computer skills, evaluating online information, and navigation on reading digital text. *Computers in Human Behavior, 55*, 486-500. DOI: 10.1016/j.chb.2015.09.042

Hedges L. V, & Olkin, I. (1985). *Statistical methods for meta-analysis*. San Diego, CA: Academic Press.

Hedges, L. V. & Vevea, J. L. (1998). Fixed- and random effects models in meta-analysis. *Psychological Methods, 3*, 486-504, DOI: 10.1037/1082-989X.3.4.486

Kitajima, M., Blackmon, M. H., & Polson, P. G. (2000). A comprehension-based model of Web navigation and its application to Web usability analysis. In S. McDonald, Y. Waern & G. Cockton (eds.), *People and Computers XIV—Usability or Else!* (Proceedings of HCI 2000, University of Sunderland, St. Peter's Campus, UK, September 5-8, pp. 357-373). New York: Springer

Lawless, K. A. & Schrader, P. G. (2008). Where do we go now? Understanding research on navigation in complex digital environments. In D. J. Leu & J. Coiro (Eds.), *Handbook of New Literacies* (pp 267-296). Hillsdale, NJ: Lawrence Erlbaum Associates.

McNamara, D. S., Graesser, A. C., McCarthy, P. M., & Cai, Z. (2014). *Automated evaluation of text and discourse with Coh-Metrix*. Cambridge, M.A.: Cambridge University Press.

McNamara, D.S., Louwerse, M.M., Cai, Z., & Graesser, A. (2013). *Coh-Metrix version 3.0* [computer program]. Retrieved 11/26/2014, from http://cohmetrix.com

Metzger, M. J. & Flanagin, A. J. (2013). Credibility and trust of information in online environments: The use of cognitive heuristics. *Journal of Pragmatics, 59*, 210-220. DOI: 10.1016/j.pragma.2013.07.012

Naumann, J., Goldhammer, F., Rölke, H. & Stelter, A. (2014). Erfolgreiches Problemlösen in technologiebasierten Umgebungen: Wechselwirkungen zwischen Interaktionsschrittenund Aufgabenanforderungen [Successful problem solving in technology rich environments: Interactions between number of actions and task demands]. *Zeitschrift für Pädagogische Psychologie, 28*, 193-204. DOI: 10.1024/1010-0652/a000134

Naumann, J., Richter, T., Christmann, U. & Groeben, N. (2008). Working memory capacity and reading skill moderate the effectiveness of strategy training in learning from hypertext. *Learning and Individual Differences, 18*, 197-213, DOI: 10.1016/j.lindif.2007.08.007

Nielsen, J. (1991). *Hypertext and Hypermedia*. San Diego, CA: Academic Press.

OECD. (2009). *PISA 2009 assessment framework – key competencies in reading, mathematics, and science*. Paris, France: OECD, DOI: 10.1787/9789264062658-en

OECD. (2011). *PISA 2009 results Vol VI: Students on line – digital technologies and performance*. Paris: OECD, DOI: 10.1787/19963777

OECD. (2012). *PISA 2009 technical report*. Paris, France: OECD Publishing, DOI: 10.1787/9789264167872-en

OECD. (2014). *PISA 2012 Results: What Students Know and Can Do – Student Performance in Mathematics, Reading and Science (Volume I, Revised edition, February 2014)*. Paris, France: OECD Publishing, DOI: 10.1787/9789264201118-en

Perfetti, C. A. (1994). Psycholinguistics and reading ability. In M.A. Gernsbacher (Ed.), *Handbook of psycholinguistics,* (pp. 849-894). San Diego, CA: Academic Press.

Perfetti, C. (2007). Reading ability: Lexical quality to comprehension. *Scientific Studies of Reading, 11*, 357-383, DOI: 10.1080/10888430701530730

Pirolli, P. (2005). Rational analyses of Information Foraging on the Web. *Cognitive Science, 29,* 343-373. DOI: 10.1207/s15516709cog0000_20.

Pirolli, P., & Card, S. K. (1999). Information foraging. *Psychological Review, 106*, 643–675. DOI: 10.1037/0033-295X.106.4.643

Potelle, H. & Rouet, J. F. (2003). Effects of content representation and readers' prior knowledge on the comprehension of hypertext. *International Journal of Human-Computer Studies, 58,* 327–345, DOI: 10.1016/S1071-5819(03)00016-8

Pressley, M. & Afflerbach, P. (1995). *Verbal protocols of reading. The nature of constructively responsive reading*. New York, NY: Routledge.

R Core Team (2015). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. URL http://www.R-project.org/.

Richter, T. , Isberner, M.-B., Naumann, J. & Neeb, Y. (2013). Lexical quality and reading comprehension in primary school children. *Scientific Studies of Reading, 17*, 415-434, DOI: 10.1080/10888438.2013.764879

Richter, T., Naumann, J., Isberner, M.-B., & Neeb, Y. (in press). *ProDi-L: Prozessortierte Diagnostik des Leseverstehens bei Grundschulkindern [Computergestütztes Testverfahren]. (Prodi-L: Process-oriented assessment of reading skills in primary school children. [Computer-based test])*. Göttingen, Germany: Hogrefe.

Richter, T., Schröder, S. & Wöhrmann, B. (2009). You don't have to believe everything you read: Background knowledge permits fast and efficient validation of information. *Journal of Personality and Social Psychology, 96*, 538-558, DOI: 10.1037/a0014038

Rouet, J.-F. (2006) *The skills of document use: From text comprehension to web-based learning*. Mahwah, NJ: Routledge.

Rouet, J.-F. & Le Bigot, L. L. (2007). Effects of academic training on metatextual knowledge and hypertext navigation. *Metacognition and Learning, 2,* 157-168. DOI: 10.1007/s11409-007-9011-z

Salmerón, L., Cañas, J. J., Kintsch, W. J. & Fajardo, I. (2005). Reading strategies and hypertext comprehension. *Discourse Processes, 40*, 171-191, DOI: 10.1207/s15326950dp4003_1

Salmerón, L., Cerdán, R., Naumann, J. (2015). How adolescents navigate wikipedia questions. *Infancia y Aprendizaje, 38*, 435-471. DOI:10.1080/02103702.2015.1016750

Salmerón, L., & García, V. (2011). Reading skills and children's navigation strategies in hypertext. *Computers in Human Behaviour, 27,* 1143–1151. DOI: 10.1016/j.chb.2010.12.008

Salmerón, L., Kammerer, Y., & García-Carrión, P. (2013). Searching the Web for conflicting topics: page and user factors. *Computers in Human Behavior, 29*, 2161–2171.

Schneider, W., & Shiffrin, R. M. (1977). Controlled and automatic human information processing: I. Detection, search, and attention. *Psychological Review, 84,* 1-66, DOI: 10.1037/0033-295X.84.1.1

Schneider, W., & Chein, J. M. (2003). Controlled & automatic processing: Behavior, theory, and biological mechanisms. *Cognitive Science, 27*, 525–559. DOI:10.1016/S0364-0213(03)00011-9

Shiffrin, R. M., & Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending, and a general theory. *Psychological Review*, *84*, 127–190. doi:10.1037/0033-295X.84.2.127

Vidal-Abarca, E., Mañá, A., y Gil, L. (2010). Individual differences for self-regulating task-oriented reading activities. *Journal of Educational Psychology*, *102*, 817-826. doi: 10.1037/a0020062.

Viechtbauer, W. (2010). Conducting meta-analyses in R with the metafor-package. *Journal of Statistical Software, 36*(3), 1-48.

Walczyk, J. J. (1995). Testing a compensatory-encoding model. Reading Research Quarterly, 30, 396-408. DOI: 10.2307/747623

Walczyk, J. J. (2000). The interplay between automatic and control processes in reading. *Reading Research Quarterly, 35,* 554-566, DOI: 10.1598/RRQ.35.4.7

Walczyk, J. J. & Taylor, R. W. (1996). How do the efficiencies of reading subcomponents relate to looking back in text? *Journal of Educational Psychology, 88,* 537-545. DOI: 10.1037/0022-0663.88.3.537

Wirth, W., Böcking, T., Karnowski, V., & von Pape, T. (2007). Heuristic and Systematic Use of Search Engines. *Journal of Computer-Mediated Communication, 12*, 778-800. DOI: 10.1111/j.1083-6101.2007.00350.x

Zoanetti, N. (2010). Interactive computer based assessment tasks: How problem-solving process data can inform instruction. *Australasian Journal of Educational Technology, 26,* 585–606.

Table 1

Demographic information per country

										On line reading			
		Age		Gender	Ever Computer used	Computer available at home	Internet connection available at home	Computer available at school	Internet connection available at school	On line Reading Dictionary	On line Reading E-mail	On line Reading News	On line Reading Topic
Country	*N*	*M*	*SD*	% female	% yes	% yes	% yes	% yes[a]	% yes[a]	% yes[b]	% yes[b]	% yes[b]	% yes[b]
Australia	2980	15.76	0.29	50.9	99.7	97.7	95.3	98.7	99.2	72.4	89.1	57.0	90.7
Austria	2623	15.80	0.29	50.1	99.5	97.5	95.5	99.2	95.3	68.1	86.3	75.4	89.1
Belgium	2807	15.85	0.28	50.0	99.3	97.2	97.4	98.7	89.8	68.2	89.7	52.3	79.4
Chile	1695	15.78	0.28	49.1	99.3	74.4	57.0	79.1	84.3	75.3	71.4	47.5	89.9
Colombia	1472	15.85	0.28	51.0	N/A[c]	48.7	34.2	N/A[c]	N/A[c]	75.4	76.1	57.2	83.3
Denmark	1270	15.74	0.28	51.8	99.8	99.1	98.8	99.5	99.3	84.7	91.4	73.8	93.8
Spain	1686	15.87	0.29	49.8	99.5	94.0	86.1	95.8	91.9	83.2	79.5	58.0	87.9
France	1304	15.86	0.28	51.5	N/A[c]	95.3	93.8	N/A[c]	N/A[c]	75.9	83.6	67.8	83.0
Hongkong	1459	15.75	0.28	46.6	99.4	98.1	98.1	97.9	89.9	87.8	86.8	85.8	91.6
Hungary	1731	15.72	0.28	49.7	99.5	92.5	84.7	94.4	96.3	79.0	93.1	76.0	87.9
Ireland	1408	15.70	0.29	49.3	99.1	93.4	93.7	97.0	95.1	52.9	71.9	41.1	78.9
Iceland	962	15.74	0.28	54.0	99.5	98.8	98.8	99.8	96.5	77.4	88.9	83.1	88.9
Japan	1197	15.77	0.29	48.7	97.8	65.5	79.6	86.5	87.4	61.4	90.1	60.6	78.7
Korea	1477	15.67	0.30	48.7	100.0	95.4	96.7	92.1	92.7	70.0	54.1	84.5	88.0
Macau	2519	15.77	0.29	51.4	99.0	97.2	97.2	97.8	91.5	79.7	77.6	78.5	73.2
Norway	1968	15.81	0.28	49.2	99.5	98.1	99.2	99.5	98.0	91.7	88.1	71.0	89.0
New Zealand	1755	15.77	0.29	50.1	99.6	94.6	92.5	96.4	98.7	69.2	85.7	51.2	90.1
Sweden	1886	15.76	0.28	50.8	99.2	98.4	98.8	99.0	98.5	81.8	85.0	63.8	90.7
Poland	1905	15.71	0.28	49.5	99.5	94.5	85.3	94.8	94.3	88.1	83.2	90.3	94.1

Note. For all variables unweighted figures are provided. Note that for this reasons figures will differ from those reported in OECD (2011). Percentages are valid percent. The exact question wordings and answer options can be found in the PISA 2009 student questionnaire for “Age”, “Gender”, “Computer available at home”, and the four on line reading activities. The question wordings and answer options for “Ever computer used” and “Computer available at school” can be found in the PISA 2009 ICT familiarity questionnaire. Both questionnaires are available at http://pisa2009.acer.edu.au/ [a] “yes, I use it” or “yes, but I don’t use it” [b]at least “several times a month”. [c] This item was part of the ICT familiarity questionnaire, which was not completed by students in Colombia and France.

Table 2

Proportion of correct responses per task and country in the present sample

	Country																		
Task code	AUS	AUT	BEL	CHL	COL	DEN	ESP	FRA	HKG	HUN	IRL	ISL	JAP	KOR	MAC	NOR	NZL	SWE	POL
E002Q01	.97	.94	.98	.97	.81	.92	.96	.97	.97	.93	.97	.92	.98	.98	.99	.93	.98	.92	.97
E002Q03	.88	.79	.89	.76	.64	.83	.78	.85	.90	.76	.87	.87	.93	.95	.90	.84	.90	.82	.80
E002Q05	.73	.60	.74	.52	.44	.55	.62	.71	.68	.51	.64	.78	.74	.87	.64	.64	.76	.72	.73
E005Q01	.89	.76	.89	.82	.64	.81	.87	.88	.90	.77	.91	.89	.91	.95	.87	.88	.92	.89	.82
E005Q02	.83	.70	.82	.67	.47	.78	.68	.87	.75	.79	.78	.85	.75	.94	.78	.85	.85	.85	.79
E005Q03	.80	.55	.77	.64	.47	.67	.66	.75	.82	.57	.74	.82	.69	.85	.80	.70	.80	.66	.67
E005Q08A	.98	.92	.92	.86	.85	.89	.90	.91	.94	.84	.95	.93	.95	.97	.95	.92	.98	.88	.94
E006Q02	.52	.27	.43	.54	.47	.35	.51	.42	.51	.48	.39	.54	.36	.64	.44	.48	.56	.44	.13
E006Q05	.44	.14	.35	.37	.17	.21	.36	.37	.16	.13	.26	.22	.44	.27	.24	.27	.44	.27	.21
E006Q06	.71	.59	.69	.56	.39	.64	.67	.66	.70	.57	.64	.71	.82	.80	.73	.61	.70	.72	.58
E011Q01a	.91	.77	.86	.79	.59	.85	.77	.84	.87	.76	.85	.90	.91	.90	.89	.88	.93	.85	.81
E011Q01b	.94	.91	.93	.96	.89	.96	.93	.93	.90	.94	.93	.93	.97	.95	.81	.97	.94	.95	.92
E012Q01	.81	.45	.64	.63	.46	.62	.57	.71	.73	.64	.79	.73	.78	.85	.69	.65	.84	.68	.64
E012Q03	.90	.76	.82	.70	.64	.80	.71	.85	.86	.73	.87	.85	.89	.93	.78	.82	.92	.88	.75
E012Q05	.65	.57	.58	.49	.42	.32	.58	.53	.45	.75	.53	.63	.56	.51	.31	.73	.70	.62	.63
E013Q01	.75	.66	.73	.69	.48	.75	.67	.70	.70	.59	.72	.82	.79	.73	.67	.77	.77	.80	.67
E013Q04	.73	.65	.70	.35	.28	.66	.51	.58	.67	.55	.71	.71	.77	.73	.67	.74	.76	.75	.56
E013Q07	.65	.51	.64	.59	.41	.55	.61	.66	.67	.46	.61	.62	.68	.72	.58	.60	.73	.63	.56
E014Q01	.80	.59	.73	.54	.42	.62	.71	.69	.85	.60	.76	.68	.84	.88	.70	.68	.78	.70	.63
E014Q06	.54	.37	.54	.42	.29	.43	.51	.48	.50	.42	.51	.48	.65	.81	.49	.39	.58	.53	.38
E014Q07	.72	.62	.73	.53	.43	.67	.63	.69	.73	.58	.72	.64	.75	.74	.63	.60	.74	.76	.62
E014Q11	.44	.42	.50	.41	.34	.43	.41	.50	.39	.38	.42	.40	.52	.59	.32	.34	.50	.45	.33
E017Q01	.56	.41	.59	.40	.21	.46	.62	.69	.43	.50	.56	.56	.60	.58	.38	.38	.60	.69	.65
E017Q04	.91	.89	.92	.78	.66	.89	.88	.92	.92	.84	.89	.93	.97	.98	.94	.92	.93	.92	.87
E017Q07	.77	.42	.70	.68	.41	.51	.64	.65	.72	.56	.79	.62	.79	.77	.58	.68	.72	.69	.72
E021Q01	.66	.57	.57	.48	.47	.54	.57	.56	.59	.65	.62	.65	.78	.75	.55	.62	.69	.63	.53
E021Q04	.78	.64	.76	.61	.48	.60	.69	.75	.82	.61	.72	.77	.81	.89	.77	.67	.80	.72	.64
E021Q05	.70	.54	.70	.49	.41	.64	.58	.78	.70	.68	.66	.74	.83	.74	.58	.76	.72	.80	.57
E021Q08	.37	.24	.36	.23	.10	.23	.25	.23	.56	.28	.32	.29	.62	.69	.32	.29	.40	.26	.22

Table 3

Correlations of person and task level predictors with potentially confounding person and task level variables

	Person level predictor comprehension skill [a]			Task level predictor navigation demands [c]	
Potential confounder	*Md* (*r*)	*Min* (*r*)	*Max* (*r*)	Potential confounder	*r*
ICT Confidence [b]	.09	-.08	.25	Number of words	-.32
Online reading	.21	.08	.36	Mean word frequency (log.)	-.13
ICT at school [b]	-.10	-.27	.07	Mean word length (syllables)	-.02
ICT for school [b]	.07	.02	.17	Flesch reading ease	.06
ICT for entertainment [b]	.01	-.10	.25	Navigation support	-.12

Note. Confidence: Self-confidence in high-level ICT tasks. Online reading: Frequency and diversity of reading online texts. ICT at school: Use of ICT at school. ICT for school: Use of ICT at home for school. ICT for entertainment: Use of ICT at home for entertainment. See OECD (2012) for details.

[a] Analyses were carried out country wise ($962 \leq n \leq 2980$)

[b] This variable was measured through the PISA ICT familiarity questionnaire, which was not administered in Colombia and France.

[c] For tasks, no country-wise analysis was necessary, since all tasks ($k = 29$) were administered in all countries.

Table 4

Fixed effects and random effects for Model 1 per country and economy

Country	β_0 (*SE*)	β_1 (*SE*)[a]	Var(b_{0u})	$\chi^2(1)$[b]	Var(b_{1p})	$\chi^2(1)$[c]	cor. (b_{0p}, b_{1p})	$\chi^2(1)$[d]	Var(b_{1t})	$\chi^2(1)$[e]	cor. (b_{0t}, b_{1t})	$\chi^2(1)$[f]
AUS	1.32 (0.34)	0.45* (0.10)	0.38	1.23	0.05	14.93*	-0.44	24.39*	0.28	697.68*	-0.48	5.93*
AUT	0.40 (0.36)	0.58* (0.10)	0.50	1.23	0.03	5.96*	-0.17	1.64	0.27	551.48*	-0.58	7.36*
BEL	1.03 (0.26)	0.25* (0.10)	0.13	0.51	0.06	14.25*	-0.61	46.46*	0.25	442.70*	-0.69	16.47*
CHL	0.34 (0.27)	0.29* (0.09)	0.22	1.64	*0.01*		*-1.00*		0.20	239.81*	-0.73	17.08*
COL	-0.39 (0.23)	0.25* (0.07)	0.08	0.39	*0.00*		*1.00*		0.12	152.07*	-0.67	12.07*
DEN	0.52 (0.32)	0.38* (0.11)	0.38	1.37	0.05	6.01*	-0.61	22.68*	0.35	293.21*	-0.63	10.10*
ESP	0.62 (0.25)	0.41* (0.10)	0.16	0.69	0.02	0.91	-0.71	15.56*	0.24	295.68*	-0.61	10.28*
FRA	0.87 (0.28)	0.31* (0.11)	0.14	0.37	0.06	3.88*	-0.65	25.53*	0.28	211.03*	-0.64	12.03*
HKG	0.97 (0.26)	0.32* (0.09)	0.00	0.00	0.02	2.77	-0.89	30.24*	0.23	284.81*	-0.46	5.94*
HUN	0.46 (0.31)	0.48* (0.10)	0.35	1.96	0.01	0.54	-0.60	6.56*	0.24	283.80*	-0.69	13.21*
IRL	0.85 (0.29)	0.32* (0.11)	0.01	0.00	0.07	10.19*	-0.47	18.20*	0.35	312.72*	-0.63	11.96*
ISL	1.03 (0.29)	0.34* (0.12)	0.32	1.80	0.07	8.46*	-0.65	21.08*	0.39	248.57*	-0.57	8.52*
JAP	1.24 (0.29)	0.31* (0.14)	0.00	0.00	0.08	18.26*	-0.63	33.42*	0.48	315.54*	-0.56	8.74*
KOR	1.61 (0.26)	-0.10 (0.12)	0.11	0.17	0.07	9.63*	-0.79	45.94*	0.39	246.05*	-0.55	8.50*
MAC	0.59 (0.29)	0.25* (0.10)	0.02	0.01	0.03	4.41*	-0.72	45.99*	0.28	542.36*	-0.68	14.90*
NOR	0.81 (0.29)	0.53* (0.12)	0.20	0.36	0.05	10.29*	-0.49	19.90*	0.39	654.35*	-0.43	4.66*
NZL	1.37 (0.31)	0.30* (0.11)	0.30	1.02	0.09	18.48*	-0.58	38.88*	0.34	400.70*	-0.62	10.57*
SWE	0.95 (0.27)	0.39* (0.12)	0.08	0.10	0.08	16.46*	-0.53	33.22*	0.39	504.41*	-0.56	9.45*
POL	0.53 (0.36)	0.50* (0.10)	0.59	2.05	0.02	1.37	-0.39	5.04*	0.27	369.89*	-0.42	3.82

Note. β_0: Fixed intercept. β_1: Fixed effect of time on task. Var(b_{0u}): Random intercept variance across units. Var(b_{1p}): Random time on task slope variance across persons. cor(b_{0p}, b_{1p}): Correlation between the random time-on-task effect across persons and the random person intercept. Var(b_{1t}): Random time on task slope variance across tasks. cor(b_{0t}, b_{1t}): Correlation between the random time-on-task effect across tasks and the random task intercept. [a] One-tailed test. [b] Model difference test, comparing a model with against a model without random unit intercept. [c] Model difference test, comparing the model with random time on task slope variance across persons (but no covariance with the random person intercept) against a model without random time on task slope variance across persons. [d] Model difference test, comparing he full model against a model with the correlation between the random person intercept and the random time on task slope across persons restricted to zero. [e] Model difference test, comparing the model with random time on task slope variance across tasks (but no covariance with the random task intercept) against a model without random time on task slope variance across tasks. [f] Model difference test, comparing the full model against a model with the correlation between the random task intercept and the random time on task slope across tasks restricted to zero.

* $p < .05$ (two-tailed unless noted otherwise).

Table 5

Fixed effects for Model 2 per country and economy: Effects of time on task, comprehension skill, and their interaction

Country	β_0 (*SE*)	β_1 (*SE*)	β_2 (*SE*)	β_3 (*SE*)[a]	β_4 (*SE*)	β_5 (*SE*)	β_6 (*SE*)
AUS	1.23 (0.31)	0.37* (0.12)	-0.21* (0.02)	-0.02* (0.01)	0.83* (0.02)	-0.06* (0.02)	-0.02* (0.01)
AUT	0.68 (0.34)	0.49* (0.12)	-0.21* (0.02)	-0.02* (0.01)	0.78* (0.02)	-0.05* (0.02)	-0.04* (0.01)
BEL	0.91 (0.24)	0.14 (0.11)	-0.12* (0.02)	0.02* (0.01)	0.87* (0.02)	-0.08* (0.02)	-0.01 (0.01)
CHL	0.77 (0.27)	0.31* (0.10)	-0.11* (0.02)	0.00 (0.01)	0.89* (0.03)	-0.06* (0.03)	0.01 (0.02)
COL	0.09 (0.21)	0.33* (0.07)	-0.02 (0.02)	-0.01 (0.01)	0.71* (0.03)	0.05 (0.02)	-0.02 (0.01)
DEN	0.72 (0.31)	0.23* (0.13)	-0.22* (0.03)	0.01 (0.01)	0.85* (0.03)	-0.07* (0.03)	-0.03* (0.02)
ESP	0.79 (0.25)	0.37* (0.11)	-0.18* (0.03)	-0.01 (0.01)	0.88* (0.03)	-0.05* (0.02)	-0.04* (0.02)
FRA	0.86 (0.25)	0.29* (0.11)	-0.13* (0.03)	0.00 (0.01)	0.80* (0.03)	-0.11* (0.03)	0.00 (0.02)
HKG	0.75 (0.26)	0.28* (0.10)	-0.13* (0.02)	0.00 (0.01)	0.73* (0.03)	-0.10* (0.02)	-0.05* (0.01)
HUN	0.63 (0.30)	0.43* (0.11)	-0.16* (0.02)	-0.03* (0.01)	0.99* (0.03)	-0.04* (0.02)	-0.03* (0.01)
IRL	0.92 (0.29)	0.25* (0.14)	-0.23* (0.03)	0.00 (0.01)	0.74* (0.03)	-0.04 (0.02)	-0.02* (0.01)
ISL	1.04 (0.28)	0.22* (0.13)	-0.14* (0.03)	0.02* (0.01)	0.82* (0.04)	-0.12* (0.03)	-0.05* (0.02)
JAP	1.03 (0.28)	0.25 (0.16)	-0.21* (0.03)	0.03* (0.01)	0.54* (0.03)	-0.13* (0.03)	0.01 (0.02)
KOR	1.32 (0.24)	-0.06 (0.12)	-0.13* (0.03)	0.00 (0.01)	0.76* (0.03)	-0.23* (0.03)	0.05 (0.02)
MAC	0.72 (0.28)	0.26* (0.10)	-0.10* (0.02)	0.00 (0.01)	0.64* (0.02)	-0.05* (0.02)	0.01 (0.01)
NOR	0.82 (0.28)	0.37* (0.13)	-0.13* (0.02)	0.01 (0.01)	0.75* (0.02)	-0.06* (0.02)	-0.03* (0.01)
NZL	1.13 (0.29)	0.26* (0.13)	-0.20* (0.03)	0.02 (0.01)	0.88* (0.03)	-0.05* (0.02)	-0.03* (0.01)
SWE	0.97 (0.27)	0.33* (0.14)	-0.18* (0.02)	-0.01 (0.01)	0.78* (0.02)	-0.06* (0.02)	0.01 (0.01)
POL	0.56 (0.35)	0.44* (0.11)	-0.15* (0.02)	-0.01 (0.01)	0.95* (0.03)	-0.04* (0.02)	-0.06* (0.01)

Note. Fixed effects. β_0: Intercept. β_1: Linear effect of time on task. β_2: Quadratic effect of time on task. β_3: Cubic effect of time on task. β_4: Effect of comprehension skill. β_5: Interaction between linear time on task and comprehension skill. Negative signs indicate a stronger effect of time on task in students with weaker comprehension skills. β_6: Interaction between quadratic time on task and comprehension skill. Negative signs indicate a more linear time-on-task effect in students with weaker comprehension skills.

[a] Two-tailed tests.

* $p < .05$ (one-tailed unless noted otherwise).

Table 6

Fixed effects for Model 2 per country and economy: Effects of navigation demands, and interactions with comprehension skill and time on task

Country	β_7 (*SE*)	β_8 (*SE*)	β_9 (*SE*)	β_{10}[a] (*SE*)	β_{11} (*SE*)	β_{12}[a] (*SE*)
AUS	-0.09 (0.26)	0.31* (0.11)	0.06* (0.02)	0.03 (0.02)	0.05 (0.02)	0.00 (0.01)
AUT	-0.15 (0.29)	0.29* (0.11)	0.04* (0.02)	0.01 (0.02)	0.04 (0.02)	0.02* (0.01)
BEL	-0.03 (0.22)	0.24* (0.10)	0.01 (0.02)	0.03 (0.02)	0.07 (0.02)	-0.01 (0.01)
CHL	-0.27 (0.22)	0.18* (0.10)	0.04* (0.03)	-0.02 (0.03)	-0.03 (0.03)	0.04* (0.02)
COL	-0.08 (0.20)	0.20* (0.07)	0.01 (0.02)	0.11* (0.03)	0.07 (0.03)	-0.04* (0.02)
DEN	-0.14 (0.24)	0.35* (0.13)	0.02 (0.03)	-0.02 (0.03)	0.03 (0.03)	0.03 (0.02)
ESP	-0.18 (0.21)	0.30* (0.10)	0.02 (0.02)	0.04 (0.03)	0.04 (0.02)	-0.01 (0.02)
FRA	-0.22 (0.23)	0.32* (0.10)	0.03 (0.03)	0.04 (0.03)	0.01 (0.03)	0.02 (0.02)
HKG	-0.06 (0.24)	0.30* (0.10)	0.01 (0.02)	0.02 (0.03)	0.08 (0.02)	-0.01 (0.01)
HUN	-0.29 (0.23)	0.17 (0.11)	0.12* (0.02)	0.04 (0.03)	0.05 (0.02)	0.00 (0.01)
IRL	-0.19 (0.27)	0.31* (0.13)	0.07* (0.03)	0.01 (0.03)	0.04 (0.02)	0.00 (0.01)
ISL	-0.02 (0.22)	0.27* (0.12)	0.00 (0.03)	-0.01 (0.03)	0.03 (0.03)	0.04* (0.02)
JAP	-0.18 (0.26)	0.47* (0.16)	-0.05 (0.04)	0.04 (0.03)	0.00 (0.03)	0.02 (0.02)
KOR	0.13 (0.22)	0.35* (0.12)	-0.03 (0.03)	0.02 (0.03)	0.02 (0.04)	0.03 (0.02)
MAC	-0.09 (0.26)	0.37* (0.10)	-0.02 (0.02)	-0.01 (0.02)	0.05 (0.02)	-0.01 (0.01)
NOR	-0.12 (0.24)	0.25* (0.12)	0.08* (0.02)	-0.01 (0.02)	0.05 (0.02)	-0.01 (0.01)
NZL	-0.06 (0.24)	0.38* (0.12)	0.02 (0.02)	0.03 (0.03)	0.07 (0.02)	-0.02 (0.01)
SWE	-0.18 (0.24)	0.32* (0.13)	0.02 (0.02)	-0.02 (0.02)	0.03 (0.02)	0.01 (0.01)
POL	-0.31 (0.26)	0.27* (0.11)	0.07* (0.02)	0.01 (0.03)	0.05 (0.02)	0.03* (0.01)

Note. Fixed effects. β_7: Effect of navigation demands. β_8: Interaction between navigation demands and linear time on task. Positive coefficients mean stronger positive time-on-task effects in high navigation demands tasks. β_9: Interaction between navigation demands and quadratic time on task. Positive coefficients mean more linear time-on-task effects in high navigation demands tasks. β_{10}: Interaction between navigation demands and comprehension skill. β_{11}: Three-way interaction between navigation demands, comprehension skill, and linear time on task. β_{12}: Three-way interaction between navigation demands, comprehension skill, and quadratic time on task.

[a] two-tailed test.

* $p < .05$ (one-tailed unless noted otherwise).

Table 7

Simple slopes for the time-on-task effect conditional on comprehension skill and navigation demands

	Time-on-task effect simple slopes by comprehension skill (CS)				Time-on-task effect simple slopes by navigation demands (ND)			
	Linear time-on-task effect		Quadratic time-on-task effect		Linear time-on-task effect		Quadratic time-on-task effect	
Country	CS = -1 SD	CS = +1 SD	CS = -1 SD	CS = +1SD	ND = -1 SD	ND = +1SD	ND = -1 SD	ND = +1SD
AUS	0.43* (0.12)	0.32* (0.12)	-0.19* (0.02)	-0.23* (0.02)	0.06 (0.17)	0.68* (0.16)	-0.27* (0.03)	-0.15* (0.03)
AUT	0.54* (0.12)	0.44* (0.12)	-0.18* (0.02)	-0.25* (0.02)	0.20 (0.17)	0.77* (0.16)	-0.25* (0.03)	-0.18* (0.03)
BEL	0.21* (0.11)	0.06 (0.11)	-0.11* (0.02)	-0.13* (0.03)	-0.10 (0.15)	0.38* (0.14)	-0.13* (0.03)	-0.11* (0.03)
CHL	0.37* (0.10)	0.26* (0.11)	-0.12* (0.02)	-0.11* (0.03)	0.13 (0.14)	0.50* (0.14)	-0.16* (0.03)	-0.07* (0.04)
COL	0.28* (0.07)	0.38* (0.08)	0.00 (0.02)	-0.04 (0.03)	0.13 (0.09)	0.53* (0.11)	-0.03 (0.03)	-0.01 (0.03)
DEN	0.30* (0.14)	0.16 (0.14)	-0.19* (0.03)	-0.25* (0.04)	-0.12 (0.19)	0.58* (0.18)	-0.24* (0.04)	-0.20* (0.04)
ESP	0.42* (0.11)	0.32* (0.11)	-0.14* (0.03)	-0.21* (0.03)	0.07 (0.15)	0.66* (0.15)	-0.20* (0.04)	-0.15* (0.03)
FRA	0.39* (0.11)	0.18 (0.11)	-0.13* (0.03)	-0.13* (0.04)	-0.03 (0.15)	0.61* (0.15)	-0.16* (0.04)	-0.10* (0.04)
HKG	0.38* (0.11)	0.18* (0.11)	-0.08* (0.03)	-0.18* (0.02)	-0.02 (0.14)	0.58* (0.14)	-0.14* (0.03)	-0.11* (0.03)
HUN	0.47* (0.12)	0.38* (0.12)	-0.13* (0.03)	-0.19* (0.03)	0.26 (0.16)	0.60* (0.16)	-0.28* (0.03)	-0.05 (0.03)
IRL	0.28* (0.14)	0.21 (0.14)	-0.20* (0.03)	-0.25* (0.03)	-0.06 (0.19)	0.55* (0.19)	-0.29* (0.04)	-0.16* (0.04)
ISL	0.35* (0.13)	0.10 (0.13)	-0.09* (0.03)	-0.18* (0.04)	-0.05 (0.17)	0.49* (0.17)	-0.14* (0.04)	-0.14* (0.04)
JAP	0.38* (0.16)	0.12 (0.16)	-0.21* (0.03)	-0.20* (0.04)	-0.22 (0.22)	0.72* (0.23)	-0.16* (0.05)	-0.25* (0.05)
KOR	0.17 (0.12)	-0.29 (0.12)	-0.18* (0.04)	-0.08* (0.04)	-0.41* (0.17)	0.29* (0.17)	-0.10* (0.04)	-0.17* (0.04)
MAC	0.31* (0.10)	0.20* (0.11)	-0.11* (0.02)	-0.09* (0.03)	-0.12 (0.14)	0.63* (0.14)	-0.08* (0.03)	-0.12* (0.03)
NOR	0.44* (0.13)	0.31* (0.13)	-0.10* (0.02)	-0.16* (0.03)	0.12 (0.18)	0.62* (0.17)	-0.21* (0.03)	-0.05* (0.03)
NZL	0.31* (0.13)	0.21 (0.13)	-0.17* (0.03)	-0.22* (0.03)	-0.12 (0.18)	0.64* (0.18)	-0.22* (0.04)	-0.18* (0.04)
SWE	0.39* (0.14)	0.27* (0.14)	-0.20* (0.02)	-0.17* (0.03)	0.01 (0.19)	0.65* (0.18)	-0.21* (0.03)	-0.16* (0.03)
POL	0.48* (0.11)	0.40* (0.12)	-0.09* (0.03)	-0.20* (0.03)	0.17 (0.16)	0.70* (0.16)	-0.22* (0.03)	-0.08* (0.03)

Note. Fixed effects.

* $p < .05$ (one-tailed).

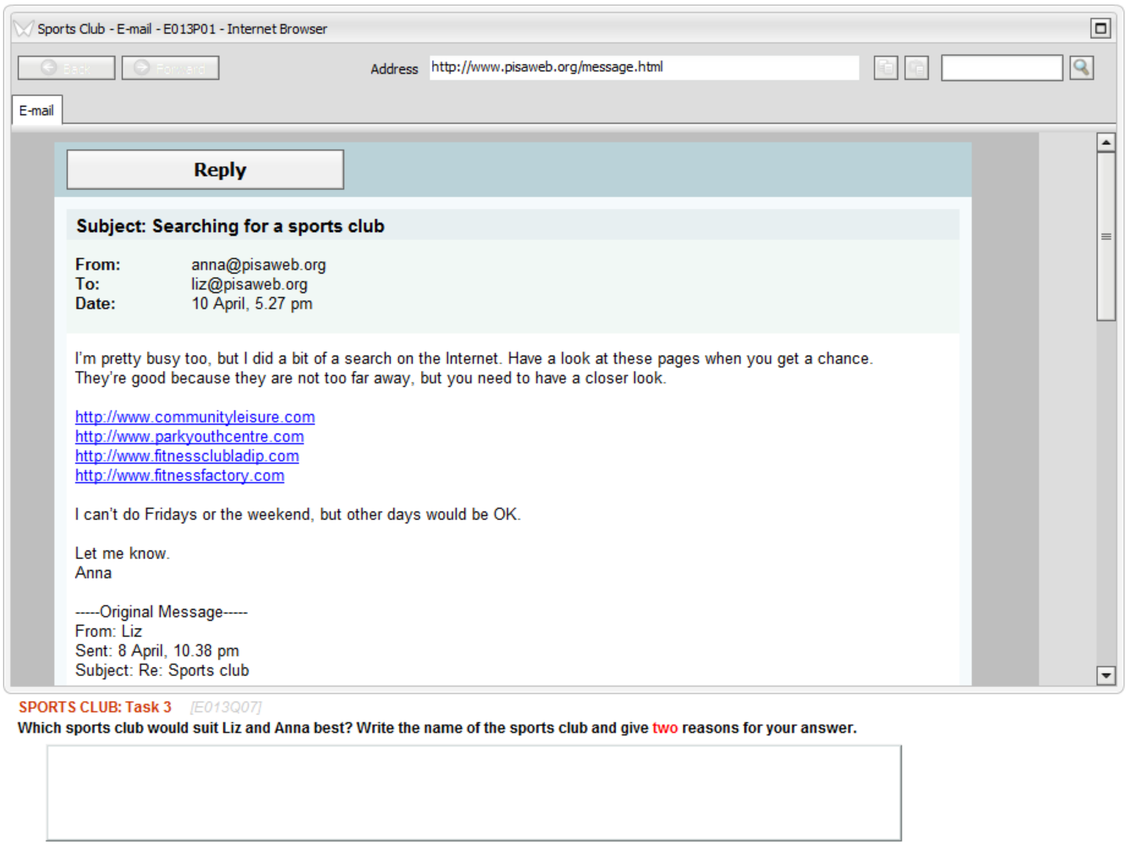
Figure captions

Figure 1: Two sample tasks from the PISA digital reading assessment. While task 3 from the unit “Sports club” (upper panel) poses high navigation demands, task 3 from the unit “Language learning” (lower panel) poses low navigation demands.

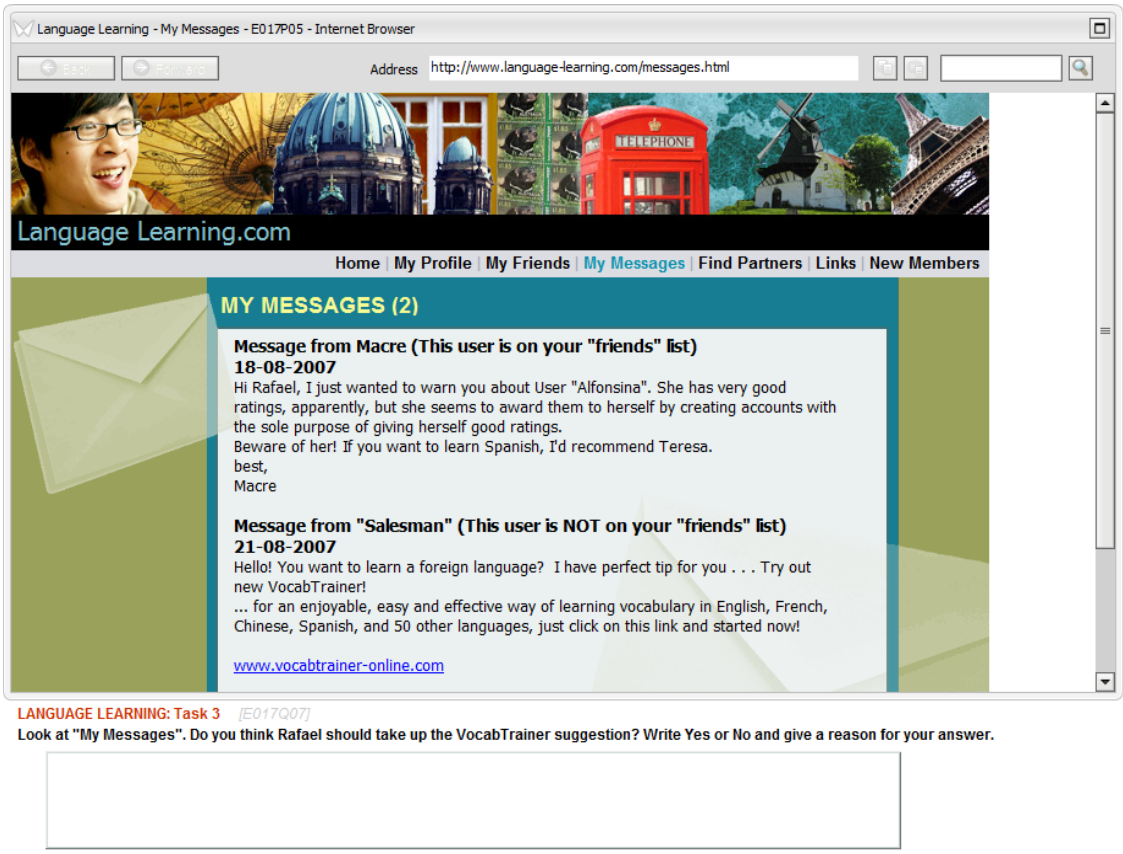
Figure 2: Per-person (upper row) and per-task (lower row) time-on-task effects in two countries. In the upper left panel (Belgium), a negative association between person skill and person-specific time-on-task effects is observed. Time-on-task effects are strongly positive for less skilled persons and become weaker with increasing skill, though not becoming negative. This pattern is the usual pattern found for most countries and economies. In the upper right panel (Korea) a negative association between person skill and person specific time-on-task effects is observed. Time-on-task effects are positive for unskilled, but negative for skilled persons. The association between task easiness and task-specific time-on-task effects in both countries (lower row) is such that time-on-task effects are positive for hard tasks, and negative for easy tasks. This is the pattern found for most countries and economies.

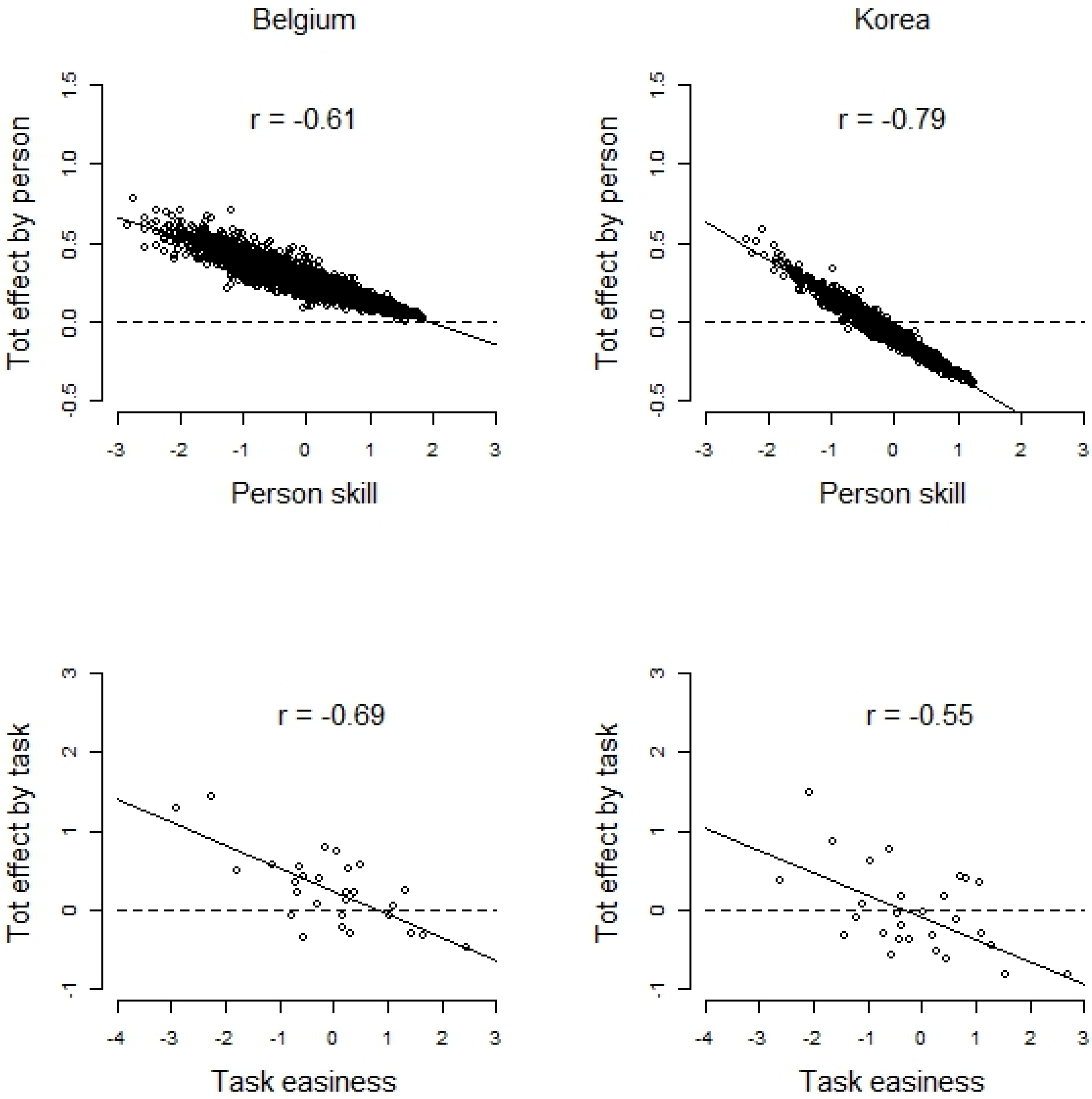
Figure 3: (a) Meta-analytically derived time on task simple slopes for persons low in comprehension skill (-1*SD*, point line) and high in comprehension skill (+1*SD*, triangle line) completing tasks low in navigation demands (-1*SD*, straight line) and high in navigation demands (+1*SD*, dotted line). (b) Distribution of linear and quadratic time on task simple slopes across all 19 countries and economies for persons low and high in comprehension skill. (c) Distribution of linear and quadratic time on task simple slopes across all 19 countries and economies for tasks low and high in navigation demands.

(a)

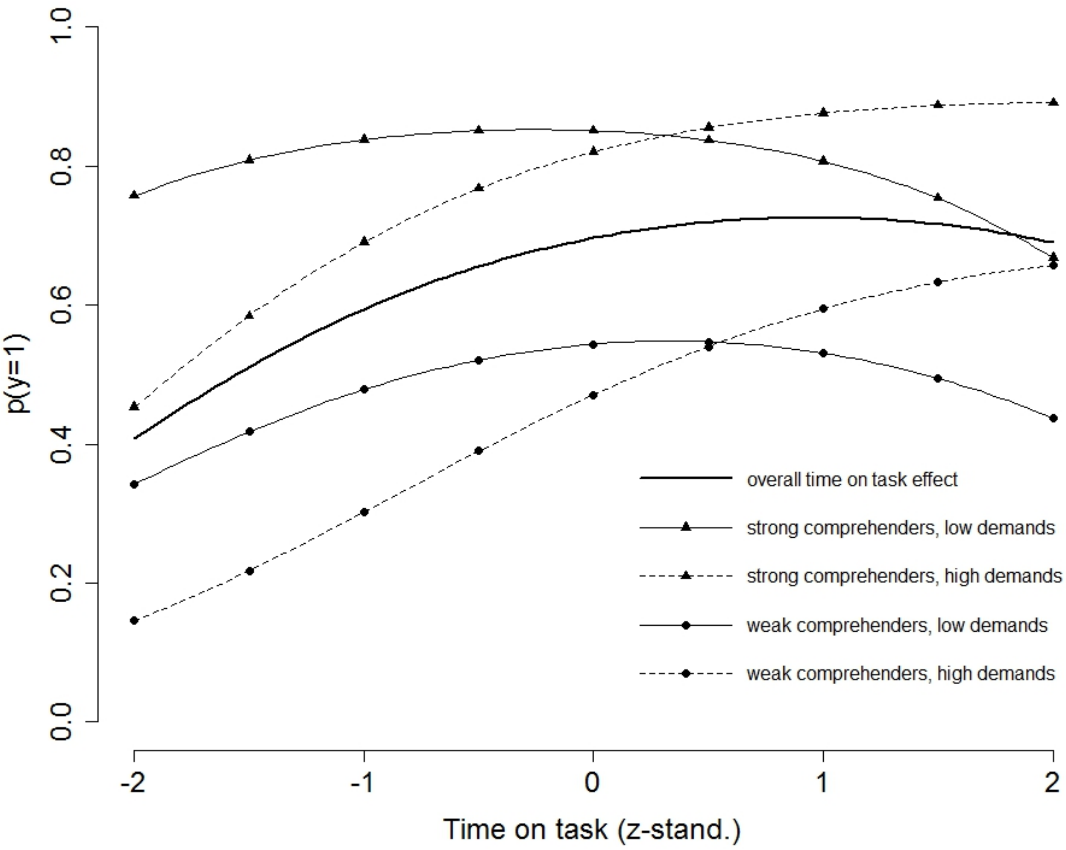

Sports Club - E-mail - E013P01 - Internet Browser
Address http://www.pisaweb.org/message.html
E-mail
Reply
Subject: Searching for a sports club
From: anna@pisaweb.org
To: liz@pisaweb.org
Date: 10 April, 5.27 pm
I'm pretty busy too, but I did a bit of a search on the Internet. Have a look at these pages when you get a chance. They're good because they are not too far away, but you need to have a closer look.
http://www.communityleisure.com
http://www.parkyouthcentre.com
http://www.fitnessclubladip.com
http://www.fitnessfactory.com
I can't do Fridays or the weekend, but other days would be OK.
Let me know.
Anna
-----Original Message-----
From: Liz
Sent: 8 April, 10.38 pm
Subject: Re: Sports club
SPORTS CLUB: Task 3 [E013Q07]
Which sports club would suit Liz and Anna best? Write the name of the sports club and give two reasons for your answer.

(b)

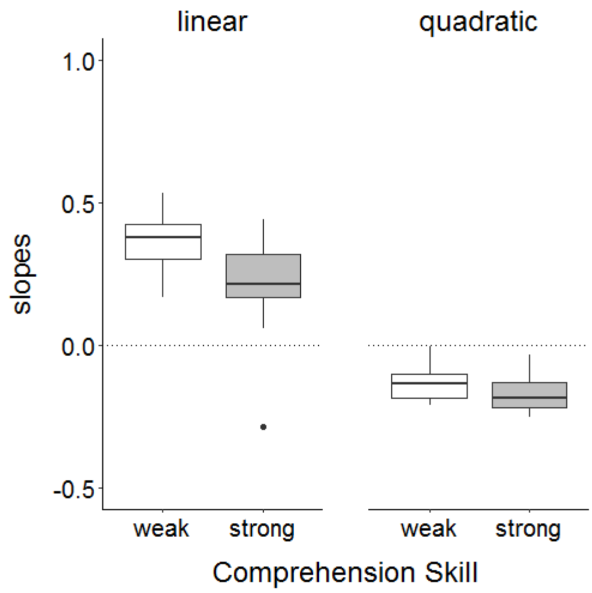

Language Learning - My Messages - E017P05 - Internet Browser
Address http://www.language-learning.com/messages.html
TELEPHONE
Language Learning.com
Home | My Profile | My Friends | My Messages | Find Partners | Links | New Members
MY MESSAGES (2)
Message from Macre (This user is on your "friends" list)
18-08-2007
Hi Rafael, I just wanted to warn you about User "Alfonsina". She has very good ratings, apparently, but she seems to award them to herself by creating accounts with the sole purpose of giving herself good ratings.
Beware of her! If you want to learn Spanish, I'd recommend Teresa.
best,
Macre
Message from "Salesman" (This user is NOT on your "friends" list)
21-08-2007
Hello! You want to learn a foreign language? I have perfect tip for you . . . Try out new VocabTrainer!
... for an enjoyable, easy and effective way of learning vocabulary in English, French, Chinese, Spanish, and 50 other languages, just click on this link and started now!
www.vocabtrainer-online.com
LANGUAGE LEARNING: Task 3 [E017Q07]
Look at "My Messages". Do you think Rafael should take up the VocabTrainer suggestion? Write Yes or No and give a reason for your answer.


Belgium
Korea
r = -0.61
r = -0.79
Tot effect by person
Person skill
r = -0.69
r = -0.55
Tot effect by task
Task easiness

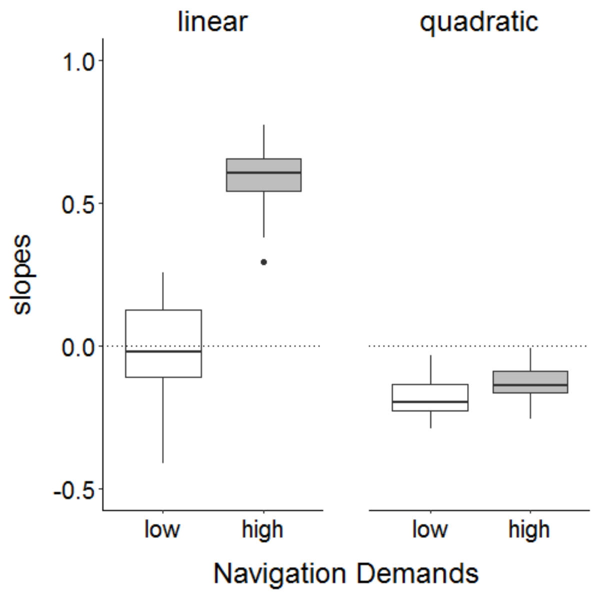
(a)


p(y=1)
0.0
0.2
0.4
0.6
0.8
1.0
-2
-1
0
1
2
Time on task (z-stand.)
overall time on task effect
strong comprehenders, low demands
strong comprehenders, high demands
weak comprehenders, low demands
weak comprehenders, high demands

(b)


linear
quadratic
slopes
1.0
0.5
0.0
-0.5
weak
strong
weak
strong
Comprehension Skill

(c)


linear
quadratic
slopes
1.0
0.5
0.0
-0.5
low
high
low
high
Navigation Demands