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Acknowledging Our Reviewers
Academic Journal Publishing and Open Access

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Human Technology: An Interdisciplinary Journal on Humans in ICT Environments started in 2005 as an open-access, peer-reviewed academic journal, published only online. At that time, the traditional printed journal model of publishing houses was quite dominant and largely uncontested. Now open-access journal publishing is growing rapidly (Björk & Solomon, 2014) and providing important alternative routes to researchers’ access to the literature in many disciplines. This editorial only discusses the gold model of open-access publishing, not the green model (traditional journal publishing and a parallel repository).¹

One of the reasons for the spread of open-access academic journal publishing in the last decade or so undoubtedly is technological development. Without the printing and fulfillment costs associated with a tangible journal, digital journal publishing is less expensive because the necessary infrastructure already exists at many universities and research institutes. More significant, however, are the recent policies of universities and funding agencies recommending or even mandating open access to results from funded research. For instance, the European Commission recommends wide dissemination of publicly funded research by means of open-access publishing.²

Another reason for the increasing popularity of open-access publishing involves commercial and economic forces. Although university libraries have always had to be fiscally selective in the journal titles available to their patrons (see, e.g., Harnad et al., 2004), recent years have seen librarians making difficult choices regarding which journals to carry. Rising subscription prices for traditional journals have resulted in many universities—even in wealthy, developed countries—no longer being able to afford to offer in their libraries all the journals that researchers need or that have been available in past decades.

Thus, open-access publishing is available to a large number of researchers, students, and those interested in research. Open access makes it possible for researchers who work in developing countries to participate in the worldwide community of researchers communicating and collaborating globally.

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As a result of growing interest in improving widespread and easy access to research reporting, traditional journal publishing can be regarded as being in a crisis (Van Noorden, 2013), with a certain tension being felt between the traditional business model of journal publishing and academia. At a time when profits of commercial publishers are high (Björk & Solomon, 2014), researchers can feel that their voluntary work, both as authors and as reviewers, is used for the benefit of publishing houses. Open-access journal publishing can be a solution to some of the concerns regarding the traditional model of publishing in an era of immediacy brought about by technology.

Models for Funding Open Access Journals

Fundamentally, the term open access (OA) means exactly what it says: Access to the material (in the case of Human Technology, journal articles) is free of charge. In reality, however, these journals are not free, as there are expenses involved in publishing of any kind (Wilinsky, 2003). The challenge for OA journal publishers, however, is determining the most appropriate OA funding model. One common classification of these publishing options refers to three models: the gold model, a hybrid model (a subcategory of the gold model), and the green model (Funk, 2007; Wilinsky, 2003). The third model (green) does not refer explicitly to journal publishing and is not discussed further.

In gold OA journals, articles are available right away, with no embargo. The costs of publishing the journal are covered in one of two ways, although Wilinsky (2003) suggested considerable variation even in these. For some journals, the publishers require an article processing charge (APC) or publication fee. Authors, or the authors’ universities or funding organizations, are required to pay a designated amount either at submission or when the paper is accepted. However, other gold OA journals do not require author fees, and Human Technology is such a journal. For the most part, the costs associated with publishing Human Technology are underwritten by the Agora Center, an interdisciplinary research unit of the University of Jyväskylä, Finland. A key member of the university community, the Agora Center’s essential research is financed by external funding and development projects, both national and international. The directors of the Agora Center took on and continue to advocate for the specialized role as an OA journal publisher within the scope of the institute’s mission because they see an important niche in the academic research role—that of interdisciplinary research into the intersection of humans and technology—that must be filled. And they feel strongly that such research should be easily and immediately available to researchers worldwide.

Hybrid journal publishing suggests a mix between traditional and OA practices. Often, in this model, an APC is charged to the author (or his/her benefactor) in order for the published paper to have immediate access for readers while, simultaneously, a subscription to the journal is required of university libraries, a process frequently referred to as “double dipping.” On average, author fees of hybrid journals are higher than in gold OA journals proper, in both cases more than €1,000 (Björk & Solomon, 2014; see also Pinfield, Salter & Bath, in press).

Whatever the OA model, the growth in the number of academic OA journals is significant, as is the increasing willingness of database aggregators to include OA journals in their offerings (Laakso, Welling, Bukvova, Nyman, Björk & Hedlund, 2011; Morrison, 2006). The Directory of Open Access Journals has grown from 300 titles in 2003 to more than 10,000 in
2015, with *Human Technology: An Interdisciplinary Journal on Humans in ICT Environments* among them.

**The Quality and Impact of Open Access Journals**

Despite the clear value to researchers around the world of achieving immediate access to a vast cache of current research without financial constraint, a dark side lurks in OA journal publishing. The proliferation of OA journals has led to breaches in scientific ethics or questionable editorial practices by some OA journal publishers, particularly those who charge APCs (see, e.g., McCabe & Snyder, 2004). Unfortunately, some OA journal publishers have been considered predatory. Jeffrey Beall, of the University of Colorado Denver, maintains a useful list of potential, possible, and probable predatory journals that advance themselves as OA academic publications. His Web site shows that, in recent years, the number of questionable journals and publishers has increased steeply. Sadly, the actions of unethical or predatory publishers tarnish the reputation of OA publishers who are consciously and actively upholding the expected scientific practices of traditional, high-quality journals.

However, researchers do have ways to identify reputable publishers. Beall’s list is indispensable for researchers wishing to vet the reputation of a journal for either submission or article citation reasons, and Declan Butler (2013) provides useful criteria in his *Nature* article. University libraries also often have up-to-date information about OA journal publishing and its caveats.

The publisher and editors of *Human Technology* recognize that disreputable OA journals can taint the perception quality and scholarly ethics of all OA journals, particularly independent, niche journals. Therefore, collaboration among our journal’s publisher, editorial staff, and editorial board provides a framework for making every effort to maintain the quality of this journal and enacting improvements as needed. *Human Technology* is based in Finland, and the publication’s integrity is guaranteed by two national classification and qualification systems. First, our journal is included in the list of academic journals of the Publication Forum, maintained by the Federation of Finnish Learned Societies. The list, prepared by the Federation in collaboration with researchers, comprises more than 20,000 national and international academic journals. Second, *Human Technology* has been awarded the Label for Peer-Reviewed Scholarly Publications by the Federation of Finnish Learned Societies. The label indicates that the peer-review process of manuscripts submitted to *Human Technology* is carried out consistently in line with the quality standards and ethical principles required by academia. Although our journal was awarded the label in May 2015, shortly after the certification program was initiated, the internationally recognized scholarly standards for review have been our practices since the journal was launched in 2005.

Further, *Human Technology* strives for high quality in a number of ways. First, our editorial policy and review process are clearly transparent, documented throughout our Web pages. Additionally, we seek out reviewers who are experts in their fields and who represent geographic diversity. Finally, the editor in chief and the managing editor, supported by the editorial board, are actively involved in the various phases of submitted manuscripts on their way to becoming articles.

The fact that *Human Technology* is an OA journal with no APC offers benefits for individuals at all stages of the scholarly research cycle: authors, researchers, universities, and
research funding agencies. For potential authors, it is a journal of high quality, but with no author fee. As articles in the journal have no embargo, the ideas and results presented in articles are immediately available for researchers via the journal’s website. The interdisciplinary journal is a platform for examining the relationship of humans and technology and entering in dialogue with other researchers. For universities and research institutes, which struggle with tight budgets, the journal gives students and researchers access to current research without subscription fees. All these benefits are particularly important for universities in developing and emerging-market countries, who have traditionally been consumers of innovative research rather than contributors to the worldwide discussion. Finally, Human Technology can serve as a quality OA dissemination partner for research reporting of innovations and new knowledge generated within funded research projects conducted in multiple venues around the world.

This Issue’s Open Access Articles

This autumn issue of Human Technology continues the ongoing commitment to OA publishing. This second issue of Volume 11 comprises three original articles, a book review, and our biennial acknowledgement of the contributions of experts from many fields in reviewing papers under consideration for publication in our journal.

In the first paper, Carolyn C. Matheus and Justin Svegliato present OpenSR, a stimulus–response testing framework with a graphical user interface. The development of the software was precipitated by an identified need of researchers from many disciplines to have access to such testing frameworks but who lacked either the ability to pay licensing fees or the programming know-how to create a system independently. OpenSR is open source, extensible, and platform independent. The testing framework clearly has much potential.

The article by Miia Ronimus and Heikki Lyytinen continues examining digital game-based reading acquisition within the context of the reading program GraphoGame, the focus of the May 2014 thematic issue of this journal. Here they compared outcomes of the reading game used in home and school environments. They showed that children who played GraphoGame at school were more engaged and used it more frequently than players at home, although parents do play a role in encouraging learning through educational games at home. The results highlight the need to further study the role of parents and teachers in game-based learning and student engagement and enjoyment, particularly in games designed for the home environment.

Gideon Mazambani, Maria A. Carlson, Stephen Reysen, and Christian F. Hempelmann studied the spread of memes in virtual communities. Their definition of meme is wider than in popular Internet culture. Following Richard Dawkins (1976), they define a meme as a unit of cultural transmissions or a unit of imitation. Their results, stemming from an analysis of four topic-related Internet forums, confirm that meme topics in line with the focus of the forum are more likely to spread than those inconsistent with the group’s focus. However, their results also challenge previous views of the role of low-status group members in the spreading of memes.

trainer. They conclude that Shaules’ book provides excellent evidence that ongoing technological advances in human brain and biological sciences can enhance theorizing, research, and application of self- and other-focused understanding of the role of culture in perception, cognition, and behavior and in providing interventions and development to improve global citizenry.

As editor in chief, I am honored and grateful to thank the scores of experts from many fields around the world who graciously have volunteered their time and knowledge in assessing manuscripts submitted to Human Technology for publication consideration. As is typical with any quality journal, only a fraction of papers submitted to Human Technology make it to review, and even fewer receive confirmation of quality and contribution from the experts who kindly accepted the invitation to review the paper. The scientific community relies heavily on the review process as part of bringing useful and significant research into the literature of many fields. So, in addition to the public acknowledgment here for the commitment these individuals have taken on to maintain high standards of scholarly publishing, I personally extend my thanks to each individual who has contributed to Human Technology in 2014 and 2015.

ENDNOTES

1. In the green model, a researcher publishes in a traditional print journal, and the publisher grants him/her the right to store the final peer-reviewed and approved article in the repository of their university or in a field-specific repository. At the University of Jyväskylä, the JYX repository (jyx.jyu.fi) serves this archival purpose for the university’s researchers as well as for Human Technology. The green model can be costly to the university because its library must still purchase access to traditionally published journals, and such subscription prices can be expensive. Another drawback in this model is that, in some cases, a publisher may not grant immediate access but instead stipulate a 6-month to 3-year embargo on access to the article.


4. See http://scholarlyoa.com/individual-journals/ for the list for Jeffrey Beall’s list of predatory journals

5. See http://scholarlyoa.com/2015/01/02/bealls-list-of-predatory-publishers-2015/ for a summary of the increase in predatory publishers and journals.

6. See http://www.tsv.fi/julkaisufoorumi for information on Finland’s Publication Forum, available also in English.

7. More information on this sufficient peer-review practices certification is available at http://tsv.fi/en/services/label-for-peer-reviewed-scholarly-publications

8. See http://www.humantechnology.jyu.fi/submission/policy.html as an example on the details on Human Technology’s peer review process.
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OpenSR: AN OPEN-SOURCE STIMULUS–RESPONSE TESTING FRAMEWORK

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Abstract: Stimulus–response (S–R) tests provide a unique way to acquire information about human perception by capturing automatic responses to stimuli and attentional processes. This paper presents OpenSR, a user-centered S–R testing framework providing a graphical user interface that can be used by researchers to customize, administer, and manage one type of S–R test, the implicit association test. OpenSR provides an extensible open-source Web-based framework that is platform independent and can be implemented on most computers using any operating system. In addition, it provides capabilities for automatically generating and assigning participant identifications, assigning participants to different condition groups, tracking responses, and facilitating collecting and exporting of data. The Web technologies and languages used in creating the OpenSR framework are discussed, namely, HTML5, CSS3, JavaScript, jQuery, Twitter Bootstrap, Python, and Django. OpenSR is available for free download.

Keywords: stimulus–response, implicit association, graphical user interface, open source framework, user-centered design.
INTRODUCTION

Stimulus–response (S–R) tests provide a unique way to obtain information about human perception by capturing implicit (i.e., automatic) responses to stimuli and attentional processes. In computer-based S–R tests, participants are asked to respond to stimuli (i.e., audio or visual) using designated keys on the keyboard, a mouse, or some other input device. Stimuli can be generated and presented in a variety of ways, including through the use of software such as the proprietary MATLAB using PsychoToolbox extensions (Brainard, 1997; Kleiner, Brainard, & Pelli, 2007; Pelli, 1997) or the open-source PsychoPy (Peirce, 2007, 2009). Via these applications, response times can be recorded and responses can be marked as correct or incorrect.

Two major challenges in using S–R tests are the extensive code needed for developing the testing framework, a task often difficult for researchers in disciplines unrelated to computer science and information technology, and the steep cost of many proprietary software packages. In this paper, we discuss the importance of establishing a cooperative relationship between computer scientists and researchers in other disciplines, illustrating how the field of computer science (e.g., software development) can be leveraged for creating applications across interdisciplinary domains. We provide first an overview of S–R tests and then the process of creating and disseminating OpenSR, a user-friendly, open-source S–R framework that provides a graphical user interface (GUI) for configuring and administering an online implicit association test (IAT) that can implicitly assess a wide range of variables. The framework is extensible, which means functionalities can be added to the framework to meet the varied requirements of researchers (Fielding & Taylor, 2002). The primary advantages of OpenSR are its applicability to online data collection by researchers across domains, its GUI for configuring S–R tests, and its open-source accessibility (as opposed to costly proprietary software). OpenSR is available for free download.1

CURRENT PRACTICES USING S–R TESTS

S–R tests are used across multiple disciplines. A widely used paradigm investigates the latency of saccades (i.e., small jerky eye movements) for detecting peripheral stimuli during perceptual discrimination tasks (Deubel, 2008). This paradigm has been used to examine numerous variables, such as the effect of stimulus onset asynchrony (i.e., the time latency between the sequential presentation of stimuli) on saccade latencies and strategies (van Stockum, MacAskill, & Anderson, 2011); the ability for humans to perform voluntary saccade commands when presented with sudden visual stimuli at varying distances (Edelman & Xu, 2009) or to inhibit saccadic responses to visual distractors (Buonocore & McIntosh, 2008); and to investigate whether endogenous visual cues (e.g., an arrow, displayed at the center of the visual field, pointing with high probability to a possible target location)—expressed by voluntarily focusing attention on a specific location without making eye movements—can suppress exogenous cues that automatically capture attention (Koelewijn, Bronkhorst, & Theeuwes, 2009). In such experiments, eye movement is tracked and recorded as participants respond to a series of tasks in which stimuli are presented on a computer screen. For example, while the eyes are focused on a central cue, symbols briefly appear at

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the cued target location as well as at uncued nontarget locations. Responses to the stimuli, measured either by external responses (e.g., pressing a key on the keyboard) or via eye-tracking software, are recorded and analyzed. Saccadic movements allow a detailed analysis of objects by bringing them onto the fovea. Located in the center of the macula region of the retina, the fovea allows sharp central vision and visual detail. When the eye is fixated on an object of interest, peripheral information is processed in order to decide where to look next. Thus, a saccade also represents a decision that must be made about the competition between a primary visual fixation and competing peripheral stimuli (Ludwig, Gilchrist, & McSorley, 2005). The impact of the competing stimuli, called the remote distractor effect, may influence how people determine where to look and what to focus on.

One purpose of such research is to examine the influence of top–down factors (e.g., attention, inhibitory strategies, or expectations) on visual responses (Bompas & Sumner, 2009; van Stockum et al., 2011). For example, saccadic movement testing is currently being used as one way to detect whether a person demonstrates signs of attention deficit hyperactivity disorder (ADHD). Some researchers suggest that symptoms of ADHD may be a result of abnormal motor responses to stimuli due to a failure to inhibit behavioral responses or focus on fixed objects (Barkley, 1997; Goto et al., 2010; Quay, 1997). Goto et al. (2010) compared voluntary control of saccades in children with and without ADHD diagnoses. Using an S–R research design framework in which visual targets were presented at a central fixation point (FP) as well as to the right and left of the FP, saccade latency and accuracy—measured through recordings of eye movements—were computed in a series of tasks.

During the tasks, participants were seated upright, were equipped with a chin rest, and faced a display that was 100 cm away from the eyes. In each trial, an FP appeared at the center of the screen and visual targets were presented randomly to the left or right of the FP at random intervals. Participants were instructed to fixate first on the FP and to perform horizontal saccades to the visual target as soon as possible. Some trials involved visually guided saccade tasks (VGSTs), and others involved memory guided saccade tasks (MGSTs). In the VGSTs, participants were instructed to fixate on the FP and to perform horizontal saccades to the visual target, which appeared for 50 ms, to the right or left in random intervals of 3 to 5 s. In the MGSTs, participants were instructed to fixate on the FP while the lateral target flashed in the randomly presented locations. Saccade toward this lateral target at this point was prohibited. When the central FP was switched off after the flashed target disappeared, participants were instructed to make a saccade to the remembered position of the flash. Saccades made to the flash while the FP was visible were judged as anticipatory errors. In a third block of trials, the antisaccade block, participants were instructed to look at a position approximately equidistant from the FP but in the opposite direction. Trials in which the participant first looked at the target and then looked in the opposite direction were judged as direction errors.

Each participant completed at least 25 trials in each block. Trials with confounding factors (e.g., head movement, poor fixation, misinterpretation of the task instructions, or saccade after reappearance of the target in the MGST) were excluded. Horizontal eye movements were measured by electrooculography. The target position and eye-movement signals were captured by a computer using a 1401-plus AD converter and Spike2 software. Results indicated that a higher percentage of spatial errors in VGST and MGST were observed in younger ADHD participants, who demonstrated response inhibitions dysfunction (i.e., an inability to inhibit behavioral responses to stimuli). However, the effect appears to change with age and prefrontal cortex
development. Children, defined as less than 15 years of age, appear to have greater difficulty suppressing reflexive saccades. The ability to suppress reflex saccade movements matures in adolescence, leaving young children with ADHD especially vulnerable to environmental stimuli. Thus, preadolescent children with ADHD symptoms may be good candidates for early treatment and behavior inhibition training (Goto et al., 2010; Rueda et al., 2004).

In social psychology, the IAT is a computer-based S–R test that has been used to examine implicit attitudes about factors such as age, race, self-esteem, and gender (Greenwald, McGhee, & Schwartz, 1998; Greenwald, Poehlman, Uhlmann, & Banaji, 2009), as well as other intergroup biases and behaviors based on weight and sexuality (Lane, Banaji, Nosek, & Greenwald, 2007). In an IAT, participants make judgments about stimuli (e.g., text or images) presented on a computer screen in a series of timed tasks; response times are recorded in milliseconds. The speed and error rate in task completion can be used to measure underlying variables. The strength of automatic association between concepts can be inferred, for instance, by measuring the time it takes to sort words according to their category membership (Greenwald, Nosek, & Banaji, 2003). Thus, the IAT may reveal implicit biases that people unknowingly have or wish to keep hidden.

An IAT is divided into sections called blocks, which consist of a series of trials (e.g., in a block in which the test participant is asked to sort items into categories, the sorting of one item via the response mechanism represents one trial). The responses from each block (including the error rate and speed at which the participant sorted the stimuli) can be used to calculate a  D-score, which represents the difference between the time it takes to sort words into stereotypically-congruent versus stereotypically-incongruent categories (Greenwald et al., 2003). D-scores can be used as dependent variables in subsequent data analyses. Participants generally find tasks easier to perform when they are congruent with existing thought processes. In other words, people generally perform tasks more efficiently when the tasks are compatible with their existing cognitive associations, whereas people generally slow down and make more mistakes when the tasks are incompatible with their existing cognitive associations (Rudman, Glick, & Phelan, 2008). Hence, the degree of difficulty should be evidenced by response time and error rate in the different tasks. Table 1 provides an overview of the series of blocks and trials typically used to create an IAT.

One application of the IAT sought to detect suicide intentions. A 2009 study, called the Army Study to Assess Risk and Resilience in Servicemembers (Tingley, 2013), investigated

<table>
<thead>
<tr>
<th>Block</th>
<th>Function</th>
<th>Purpose</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Practice</td>
<td>Introduce participants to the target-concept dimension</td>
</tr>
<tr>
<td>2</td>
<td>Practice</td>
<td>Introduce participants to the attribute dimension</td>
</tr>
<tr>
<td>3</td>
<td>Practice</td>
<td>Present combinations of congruent pairs of stimuli</td>
</tr>
<tr>
<td>4</td>
<td>Test</td>
<td>Present combinations of congruent pairs of stimuli</td>
</tr>
<tr>
<td>5</td>
<td>Practice</td>
<td>Introduce participants to the reverse position of the attribute dimension on the screen</td>
</tr>
<tr>
<td>6</td>
<td>Practice</td>
<td>Present combinations of incongruent pairs of stimuli</td>
</tr>
<tr>
<td>7</td>
<td>Test</td>
<td>Present combinations of incongruent pairs of stimuli</td>
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the mental health and suicide risk among United States Army soldiers. In this application of the IAT, the word *Life* appeared in the upper left corner of the computer screen and *Death* appeared in the upper right corner. Stimuli words associated with *Life* or *Death* appeared one at a time on the computer screen, and participants pressed one of two keys to sort words such as *alive* and *survive* with *Life* and words such as *funeral* and *die* with *Death*. The categories were then changed, with *Me* appearing in the upper left corner and *Not Me* appearing in the upper right corner. A new set of stimuli, such as *myself* and *mine* as well as *theirs* and *them*, were sorted similarly to the first block. The categories then appeared in groups: *Life or Me* and *Death or Not Me*. This forced participants to press the same key to associate *alive* and *survive* with *Life or Me*. Additionally, *funeral* and *die* were associated with *Death* and *Not Me*. In theory, greater speed with fewer errors\(^2\) indicated a greater association between the participant and living. In the next block, the screen position of *Life* and *Death* were switched and participants sorted words into incongruent categories: *Death or Me* and *Life or Not Me*. Greater speed with fewer errors in this set of trials indicated a greater association between the participant and dying.

This application of the IAT, which deviates from more standard uses, attempts to deal with a growing issue for military personnel. However, the IAT is more often used to measure a wide variety of variables in the discipline of social psychology, such as attitudes about race, age, and gender. In these cases, the variables under study populate the attribute and target-concept dimensions. For example, White and White (2006) used the IAT to examine stereotypes about gender and occupation, proposing that certain occupations are stereotyped as masculine (e.g., engineer) or feminine (e.g., elementary school teacher). In their study, characteristics associated with occupations composed the target-concept dimension of the IAT, and gender—represented by stereotypical male and female proper names—composed the attribute dimension of the IAT.

The parameters for creating an IAT are similar regardless of what variables are being studied. Researchers simply populate the attribute and target-concept dimensions of the IAT using stimuli associated with the variables under study.

In summary, the IAT is a computer-based word-sorting test that measures the strength of automatic associations among concepts. The epistemological grounding of the IAT is that people will perform tasks more efficiently (i.e., more quickly and with fewer errors) when the associations are compatible with their existing thought processes. Thus, biases can be implied based on the difference in time and quantity of errors in completing stereotypically congruent versus incongruent tasks. For example, people who have a bias toward living will more quickly identify with concepts associated with being alive (e.g., breathing, survive), whereas people who may have suicidal tendencies (i.e., a bias toward death) will more quickly identify with concepts associated with being dead (e.g., funeral, die; see Tingley, 2013).

**USER-CENTERED DESIGN**

From the perspective of researchers, the primary problems with designing S–R studies that utilize an IAT are the costly proprietary software and extensive programming experience necessary to create and administer an IAT. That is, current options for creating an IAT do not adequately take into account the needs of the user (i.e., the researcher designing and administering the test). This is a common problem, as pointed out by Nielsen (2005, p. 2): “The vast majority of user interface design decisions are made based on the designer’s personal taste.
If we are lucky, the designer may venture a guess at users’ needs, but that is as far as it goes.” OpenSR provides one way to bridge that gap and enhance current practices through a framework that provides researchers the ability to configure, administer, and analyze an IAT.

The primary goal of this project was to provide researchers with an easy way to create an IAT by providing a framework that specifically meets the design needs of researchers across a broad range of disciplines. Thus, the goal was to provide a tool that is both easy to use and useful. When systems are perceived as being difficult to use, users may avoid them. On the other hand, people are more likely to use systems that they perceive as easy to use. Several models have been proposed to explain decision-making processes for accepting and using new technology, such as the technology acceptance model (TAM; Davis, 1989), the information system (IS) success model (DeLone & McLean, 1992, 2003), and the unified theory of acceptance and use of technology (Venkatesh, Morris, Davis, & Davis, 2003).

The TAM (Davis, 1989), developed to help explain how users accept new technology, examines actual or intended use of a system. More specifically, the TAM suggests that people are more likely to use a new system if they perceive it as being easy to use (A. B. Matheus, Matheus, & Neely, 2014). A revised version of the TAM—the TAM3 (Pearson & Saunders, 2013)—also evaluates factors that influence how people perceive the ease of use and usefulness of a technology (e.g., individual differences, system characteristics, and social influence), which may influence intentions to use a system. Similarly, the IS success model (DeLone & McLean, 1992, 2003) examines factors related to user satisfaction and intentions to use a system. These researchers identified system quality, information quality, use, user satisfaction, individual impact, and organizational impact as significant factors.

The unified theory of acceptance and use of technology (UTAUT) is another model that examines intentions to use a system (Venkatesh et al., 2003). The model was tested in a study in which users completed a satisfaction survey regarding their experience with a new, mandated software system (Venkatesh et al., 2003). Four constructs related to system usage were identified in the study: performance expectancy (i.e., perceived usefulness), effort expectancy (i.e., perceived ease of use), attitude (i.e., user’s affect), and social influence (i.e., whether or not the user was influenced by other people). A related study illustrates the application of these models. Using structural equation modeling, A. B. Matheus et al. (2014) used elements from the TAM, the IS success model, and the UTAUT as a foundation for examining the impact of four constructs—perceived information quality, perceived design quality, perceived usefulness, and perceived ease of use—on performance in a Web-based task. The goal was to determine what factors influence the successful use of the World Wide Web, which represented the use of a system. The results indicated a number of findings related to system usage, including (a) when users perceive that a Web site has good design quality (e.g., is well organized with links that are easy to find and use), they are more likely to believe the information on the Web site is valuable and accurate as well as easy to use when finding a specific Web site; (b) users who find Web sites easy to use (e.g., displays and labels are easy to read) perceive that Web site to be more useful for completing tasks; (c) users who perceive a Web site to be useful (e.g., able to adequately and effectively meet task needs) are more successful overall in completing tasks; and (d) users who perceive information on a Web site to be of high quality are more likely to believe that the Web site can effectively meet their needs in completing a task.
Taken together, people are more likely to use a system they perceive as being easy to use and useful (e.g., it adequately meets their needs). Many people have come to expect an interactive, user-friendly experience with technology, with programs that can be easily configured. A key component of usability is a human-centered design interface and easy to use GUI.

**THE OpenSR FRAMEWORK**

The framework of a computer-based S–R instrument provides a platform for expanding the nature of the variables that can be examined, and Web-based applications provide an avenue for expanding the demographic of potential participants. However, some programs lack usability and accessibility for researchers who are not skilled programmers or who simply cannot afford expensive licensing fees. Other programs are open-source (e.g., free); however, many lack a GUI and are only configurable via a command-line program. Table 2 provides a comparison of available software packages that support S–R reaction-time experiments.

<table>
<thead>
<tr>
<th>Software</th>
<th>License</th>
<th>Operating System</th>
<th>GUI</th>
<th>Browser Based</th>
<th>Stimuli Options</th>
<th>Input/Output Options</th>
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<tr>
<td>Affect 4.0</td>
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<td>W</td>
<td>✓</td>
<td>X</td>
<td>I, A</td>
<td>K, Mo</td>
</tr>
<tr>
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<td>T, I, A, V</td>
<td>K, Mo, Mi, J</td>
</tr>
<tr>
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<td>W</td>
<td>✓</td>
<td>X</td>
<td>I, A, V</td>
<td>K, Mo, J</td>
</tr>
<tr>
<td>Expyriment</td>
<td>Open</td>
<td>W, M, L</td>
<td>✓</td>
<td>X</td>
<td>T, I, A, V</td>
<td>K, Mo, RB</td>
</tr>
<tr>
<td>Inquisit</td>
<td>Proprietary</td>
<td>W, M</td>
<td>✓</td>
<td>✓</td>
<td>T, I, A, V</td>
<td>K, Mo, Mi, RB</td>
</tr>
<tr>
<td>OpenSesame</td>
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<td>✓</td>
<td>X</td>
<td>T, I, A</td>
<td>K, Mo</td>
</tr>
<tr>
<td>OpenSR</td>
<td>Open</td>
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<td>✓</td>
<td>✓</td>
<td>T, I, V</td>
<td>K, Mo</td>
</tr>
<tr>
<td>Paradigm</td>
<td>Proprietary</td>
<td>W, iOS</td>
<td>✓</td>
<td>X</td>
<td>T, I, A, V</td>
<td>K, Mo, Mi, J, RB</td>
</tr>
<tr>
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<td>✓</td>
<td>X</td>
<td>I, A, V, VG</td>
<td>K, Mo, J</td>
</tr>
<tr>
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<td>Open</td>
<td>W, M, L</td>
<td>✓</td>
<td>X</td>
<td>T, I, A, V, RD</td>
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</tr>
<tr>
<td>PsychToolbox</td>
<td>Open*</td>
<td>W, M, L</td>
<td>X</td>
<td>X</td>
<td>T, RD, S, VG</td>
<td>K, Mo</td>
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<tr>
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<td>K, Mo, Mi, TS</td>
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<tr>
<td>Vision Egg</td>
<td>Open</td>
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<td>X</td>
<td>X</td>
<td>T, I, V, RD</td>
<td>K, Mo, Mi, RD</td>
</tr>
</tbody>
</table>


*Requires MATLAB.*
OpenSR provides several advantages for creating and administering an IAT over other software. First, it is open-source and, thus, a good option for researchers who lack funding to purchase costly licenses. Second, OpenSR can run on all major computer software platforms (i.e., Windows, Macintosh, and Linux). Third, although OpenSR is not the only framework that provides a user-friendly GUI, it is one of few IAT frameworks that is browser-based and does not require researchers to download and install plug-ins. Another browser-based option, Inquisit, is not open-source, charging fees to license. OpenSR incorporates the primary means of input for a standard IAT (i.e., keyboard and/or mouse). If researchers desire additional features beyond those provided by the current version of OpenSR, then the open code base allows them the ability to work with programmers to extend the functionality.

One of the biggest challenges of IAT S–R tests is developing the extensive code needed to customize and administer the test, which can be difficult without programming experience (Peirce, 2007, 2009). Thus, a user-friendly GUI is of great benefit for researchers from different disciplines who may not have in-depth programming knowledge in that they can easily customize and administer S–R tests (C. C. Matheus & Svegliato, 2013). GUI features, which vary by software, provide user-friendly capabilities for creating an S–R test and specifying the parameters of the test. For example, some proprietary software, such as Paradigm and E-Prime, include a GUI with mouse click-drag-and-drop functionality for specifying testing features, such as adding and customizing instruction sets and trial blocks (e.g., configuring stimuli types and trial identifiers, setting the number of blocks and the number of trials within each block, and specifying inter-trial intervals).

Similar to OpenSR, some S–R software, such as Presentation, Psykinematix, and OpenSesame, have GUIs with simple test-design capabilities through which test creators can navigate the menus of options to design and customize tests and procedures and to select options for exporting data. Test specifications are customized by using a mouse to click through forms to enter preferences for instruction sets, stimuli, and blocks and trials. This type of interface is customary for many systems and familiar to researchers. Using standard interface objects (e.g., list boxes, drop-down boxes, and pull-down menus) provides navigation consistency and is intended to reduce the learning time required by users of a new system (Dennis, Wixom, & Tegarden, 2012).

The current paper addresses the aforementioned challenges by presenting OpenSR, an S–R testing framework with a user-friendly GUI that can be used for the creation and administration of an IAT, including the ability to easily customize the testing parameters. Features of OpenSR include (a) a Web-based framework, enabling researchers to administer an IAT via the Internet to participants in any geographical location who have Internet access; (b) an open-source user-friendly framework that is platform independent and can be implemented on most devices (e.g., personal computers and tablets) using various operating systems (e.g., Windows, OSX, Linux); (c) scripting capabilities for automatically generating and assigning participant identifications and tracking, for assigning test participants to different condition groups, and for automatically forwarding test participants to external Web sites, if needed; (d) procedures for collecting and exporting data; and (e) procedures for customizing the program for use in a variety of IAT studies. The remainder of this paper describes the background, development, rationale, features, and applications of OpenSR, as well as the potential to extend to applications beyond the IAT. This information is explained by looking at three distinct facets of configuring, presenting, and analyzing an IAT: the test configuration phase (which includes all aspects of the researcher’s
test design and implementation prior to the test presentation phase), the test presentation phase (which is completed by the test participants), and the analysis phase (which encompasses all aspects of data storage and the researcher’s extraction and viewing of data for analysis).

Test Configuration Phase: The OpenSR Dashboard

Every IAT comprises multiple steps and decisions related to the experiment’s research goal(s), design, and implementation. Most of these steps and decisions take place within the test configuration phase of the OpenSR dashboard. The researcher’s specifications within this phase will have implications for both the test presentation phase and analysis phase, described below, but are intended to facilitate both. OpenSR’s test configuration phase includes a variety of tools to assist the researcher in test design, all found within the administrative dashboard.

A significant contribution of OpenSR is its user-friendly interface for creating S–R tests that provides researchers a functional tool for creating and administering an IAT, including capabilities for creating and configuring the presentation of the test (i.e., collecting input via forms to render the final presentation of the IAT) and collecting, storing, and retrieving data from the test. Researchers wishing to use OpenSR are provided a simple dashboard offering three primary services: (a) authentication, (b) flat page, and (c) test. Each service comprises several modules, and each module offers a set of associated functionalities (see Figure 1).

Authentication Service

The authentication service allows researchers to specify authorization (i.e., the list of researchers who can access the administrative dashboard) and entitlements (i.e., what actions
those researchers can take within the administrative dashboard). The functionality of this service is contained within two modules: user management and group management. The user management module provides researchers with the ability to add a test manager by specifying a username and password. The group management module allows researchers to add a test manager to a specific group with predefined permissions. For instance, a group of researchers (i.e., test managers in this case) might be given the ability to administer a test and view test results but not modify the test itself (see Figure 2).

**Flat Page**

The flat page service provides researchers with the ability to manage Web pages that appear on a test (i.e., one component of the OpenSR interface that test participants can directly see and interact with). Researchers can create and manage the introduction, informed consent, experimental and control groups, and confirmation pages via this module. These pages can then be associated with a test, as is discussed in the next section. By using a WYSIWYG (What You See Is What You Get) editor, researchers can style and design Web pages to their preferences and goals. In order to create a flat page, the researcher must specify a URL (i.e., the page’s unique Web address), a title, and the content.

**Test**

In the test service, researchers can create and manage all aspects of a test (see Figure 3). This functionality is contained within four modules, shown in Figure 1: Test, block, category, and block stimuli order. The test module allows researchers the ability to create, delete, or modify
components of tests. For example, a researcher can associate the introduction, informed consent, experimental and control group, and confirmation pages with a test, set a password, set key binds (e.g., specifying keyboard options for responses or mouse click), add a link to an external Web page or survey, and create a confirmation page. If a link to an external survey (e.g., SurveyMonkey or other Web survey application) is provided when setting up the test, participants will be automatically directed to the external survey Web site. Upon completion of the survey, participants will be automatically redirected back to OpenSR. If it is desired, survey order effects can also be configured at this point. For example, test participants with even identifiers can be directed to one version of a survey, whereas participants with odd identifiers can be directed to a different survey version.

The block module allows researchers to customize many aspects of the test block content. For example, the content for test instructions and test presentation (e.g., font style, color, and other formatting options) can be customized. Researchers can also specify stimuli to be presented in a particular order, designate practice versus testing blocks, set the number of trials per block, designate the intertrial interval (i.e., the specified time between the presentation of each stimulus) and the trial interval (i.e., the specified length of time each stimulus is presented). In addition, researchers can link blocks to a designated test and define the screen presentation and location of stimuli, designated as primary and secondary, left and right categories (see Figure 4).
Figure 4. The OpenSR add block form to customize content and process of test blocks.

The category module allows researchers to manage the categories of stimuli within each block. Researchers can specify the name of the category, choose text color, and designate the text and/or images for stimuli (see Figure 5). A category is not restricted to one particular type of stimuli.

The block stimuli order module allows a researcher to present the stimuli in a particular order, if desired, using drag-and-drop functionality. Alternatively, the stimuli can be presented in random order (see Figure 6) using Math.random(), a built-in JavaScript function for generating random numbers. Math.random() is a pseudorandom number generator and, as a result, the probability of generating each number is not equal but approximately the same. A pseudorandom number generator is used because true random number generators cannot exist on computers insofar as computers are deterministic machines. For the purposes of selecting stimuli during a participant’s test, however, a pseudorandom number generator is sufficient because the user cannot perceive the slight unevenness of the probability distribution across every number.
Figure 5. The OpenSR add category form to customize the stimuli associated with designated categories.

Figure 6. The OpenSR change stimuli order form to customize stimuli order in test design.

Test Presentation Phase

A key aspect of any IAT is the actual test: the test participants and their responses. OpenSR allows researchers to design and manage every aspect of the test participants’ experience in the online test environment. In this section, we describe the experience of OpenSR from the test participant’s perspective.

An IAT within the OpenSR system comprises several Web pages. Upon first accessing the Web application through a URL specified by a researcher, the test participant is presented with the Test Selection page. Test participants are then prompted to select a test and enter a password to gain access. Test participants can forego test selection and supply only a password if provided with a direct link to the test by the researcher. After successfully entering the
password and clicking Continue, the test participant is presented with an Informed Consent page, which is standard protocol for research studies involving human subjects. Test participants are then prompted to click Next, at which point they are redirected to the optional Introduction page if it had been configured by the researcher. Clicking Next, from either the Informed Consent page or the Introduction page, the participant may be presented with a Primer page. The information and/or instructions on the Primer page are specified for each experimental or control group by the researcher to meet his/her particular testing goals. Following the Primer page, participants proceed to the Test page, where the first set of test instructions is presented. For example, verbiage for IAT instructions involving a keyboard input device could be,

Put your middle or index fingers on the F and J keys of your keyboard. Words representing the categories at the top of your screen will appear one by one in the middle of the screen. If the item belongs to a category on the left, press the F key. If the item belongs to a category on the right, press the J key. Items belong to only one category. If you make an error, an X will appear. Fix the error by pressing the other key. Try to go as fast as you can while making as few mistakes as possible.

Test participants are then prompted to press the space bar in order to proceed and, thereafter, are presented with the blocks of trials as set up by the researcher. The flow of the IAT is linear. Once a section of the testing is complete, the test participant is not given an option to return to previous sections. This also implies that there are no branch points within the test: All test participants must follow the same sequence of pages until completion.

Upon completion of the test, participants are prompted to click Next to finish the test, or they may be redirected to an external Web site (e.g., SurveyMonkey) if the researcher configured the test that way. After completion of the external survey, the test participant is automatically redirected back into the OpenSR test site. Whether the test participant has been sent to an external site and returned to the Open SR site or has just pressed the Next button following the completion of the test blocks, the participant is directed to a confirmation page which notifies him/her that the test has been completed. At this point, the participant exits the site. Figure 7 presents a model of the process that the test participants’ experience.

**Data Analysis Phase**

The results module of the OpenSR framework contains the test results of participants. As test participants complete blocks of trials, the data (e.g., each trial response from the block) are uploaded and stored in a database on a server. Researchers access the test results through the administrative dashboard, which displays a complete list of participant tests and results. Researchers can sort results by group or by test (see Figure 8).

OpenSR currently records and exports the following information for each trial of each practice and test block: date, time, group assignment (i.e., experimental versus control), block title, designation of practice or test block, primary and secondary right and left categories (i.e., category labels), stimulus presented in each trial, and latency and correct versus incorrect status for each trial. Researchers can export data as comma-separated values directly into an Excel spreadsheet or another statistical program, such as SPSS for statistical analysis (see Figure 9).
Figure 7. Flow of the OpenSR process from participant’s experience. Solid lines (→) represent mandatory testing path process. Dotted lines (---→) represent optional testing path process that can be specified by researchers during test configuration in the administrative dashboard.

Figure 8. The OpenSR dashboard participant filter options.
OpenSR FRAMEWORK DESIGN

OpenSR is a Web-based application that must be installed on a Web server. Depending on the needs of the researcher, the software can either be installed in a lightweight preview environment or a full production environment. The first approach leverages a cloud-based integrated development environment (IDE), which is an online source code editor that provides workspace to write, test, and run software on a dedicated Web server (examples of cloud-based IDEs include Cloud9, Codeanywhere, Kodingen, and SourceKit). These environments can simplify the installation process. However, because IDEs are used primarily for development and testing, they lack scalable databases and may be slow during periods of increased network traffic. Nevertheless, a lightweight cloud-based IDE provides an ideal environment for the development and testing phases. A more robust approach for installing and deploying OpenSR is a dedicated Web server that does not operate in the cloud. The downside to this approach is that more technical expertise is needed for setup. For example, the Web server must have the following software installed and configured: Django 1.5, Python 2.7.6, Apache, and a relational database system, such as PostgreSQL, MySQL, or SQLite. Additional Django and Python packages must be installed as well, including psycopg2 and django-sortedm2m. However, this approach provides several benefits above and beyond the lightweight IDE approach. Namely, the software can have a larger database, runs faster, and can handle increased network traffic depending on the underlying hardware.

Numerous technologies were used in the development the test configuration phase (i.e., the design of the IAT) to facilitate the presentation phase (i.e., the presentation of the IAT to the test participants) and the analysis phase (i.e., retrieving and formatting IAT data). OpenSR was developed using several computer languages, namely HTML5, CSS3, Python 2.7.2, and JavaScript. The core functionality includes an IAT generator, a configuration GUI, and data retrieval tools. Session handling, page serving, and test result output file generation are handled using Django, which is a Python Web framework. The interactive component of the IAT is built in JavaScript, a client-side scripting language, allowing participants to interact with the application without refreshing the Web browser.

Figure 9. The OpenSR dashboard option for exporting data as CSV (comma-separated values) for analysis.
Python

Python is an extensible open-source development language capable of interfacing with computer hardware. We chose Python for its excellent readability due to enforced formatting and concise yet intuitive syntax, making code easy to read and debug. Additional benefits are that it fosters rapid application development and features extensive object-oriented capabilities and many high-level data types, such as dictionaries, lists, and sets (Hughes, 2008; Raymond, 2000). The standard libraries integrated into the language are robust and several stimuli libraries—such as Pyglet and NumPy—are already built in, thus reducing the need for platform-specific code. In short, Python is an agile language that is intuitive and easy to use and provides advanced functionality leveraged by large-scale projects (Peirce, 2007, 2009). For OpenSR, Python was used in conjunction with Django to create the Web server. Specifically, when a test participant accesses OpenSR in his/her Web browser, a message is sent to the Python Web server. The Web server then generates the test and sends it back to the test participant’s browser to be displayed.

Django

Django is a high-level Python Web framework that supports dynamic Web pages for the entire system. For example, as a researcher or test participant interacts with the program, Django generates and delivers the appropriate Web page to the client’s browser window. Instead of using the scripting language PHP to generate dynamic Web pages, we selected Django for multiple reasons. First, the Django framework fully supports object-relational mapping. Data models implementing dynamic database access application programming interfaces can be defined rather than relying on advanced queries to interact with the database, thus decreasing complexity while also reducing development time. Second, an administrative interface is automatically generated upon data model creation and registration, allowing development to focus on the extensibility and the flow and logic of the application. Third, Django features a flexible template system consisting of an extensible and intuitive template language that decouples the application logic from the visual design of the Web site. This separates the design, content, and implementation of the application into distinct modules, making OpenSR extensible for future adaptations (e.g., researchers have the ability to add additional features). Finally, the general emphasis on the Don’t Repeat Yourself principle reduces both the complexity and the length of application logic and aims to reduce the redundancy of information and application logic throughout a system. Django aids in facilitating test creation and presentation for OpenSR.

JavaScript and jQuery

JavaScript is a standard Web programming language; jQuery, a popular library written in JavaScript, gives the ability to dynamically change the content on the screen without refreshing the browser. This comprehensive framework, featuring HTML (Hypertext Markup Language) manipulation, asynchronous server interaction, event handling, and numerous animations and effects enhance the functionality of JavaScript. We used JavaScript because the code is executed on the client side, allowing dynamic interaction with the IAT without the need to
refresh the test participant’s Web browser. Most importantly, the application logic for OpenSR uses JavaScript and jQuery, chosen for their accurate time measurement. Response times could not have been recorded with millisecond accuracy without using JavaScript and jQuery.

**HTML5 and CSS3**

There is an increasing need to design visually appealing Web pages that are easy to customize and interact with (Wu, Hu, & Shi, 2013). HTML5 and Cascading Style Sheets level 3 (CSS3) are Web technologies that allow users to control visual presentation and user interaction. In general, HTML is a language for describing elements and attributes of Web pages. CSS3 is a graphical guideline that incorporates style and formatting rules for specifying visual presentation properties (Bolin, Webber, Rha, Wilson, & Miller, 2005; Comai & Mazza, 2012; Raman, 2009). Both HTML5 and CSS3 are standard Web technologies to the extent that Web browsers (e.g., Opera, Google Chrome, Mozilla Firefox, Safari, Internet Explorer) can appropriately interpret and render HTML5/CSS3 pages. HTML5 is used to organize the content in OpenSR, and CSS3 is used to style the content, such as the background color, font family, and the visual rendering and formatting of various elements like input fields, buttons, and text areas. In essence, HTML5 organizes the content of the page, whereas CSS3 styles and lays out the content. Both HTML5 and CSS3 were selected for the development of OpenSR to handle the design of the entire Web application—including the administration control panel and the IAT—thus allowing researchers the ability to easily create, customize, and present an IAT for their own purposes.

**Bootstrap**

Bootstrap was used in the design of OpenSR’s IAT specifically to support the styling and design of pages and the dynamic features of the application. Bootstrap is a relatively easy framework for creating attractive Web sites. We utilized the Bootstrap framework because it eases the aesthetic design of the application by automatically styling all elements (Lerner, 2012) and ensures compliance with the standard Web development conventions and protocols for Web design and architecture. Most importantly, the framework supports a fluid layout. Pages built using Bootstrap work on any device regardless of the screen resolution, allowing an application to be used on mobile devices and traditional computers.

In summary, the technologies used in the development of OpenSR provide a user-friendly experience for anyone interested in creating, customizing, and administering an S–R test such as the IAT. Python, an extensible open-source development language, was used to develop the OpenSR framework. Django, a Python Web framework, was used to generate and deliver Web page requests to any user’s browser window. HTML5 and CSS3 were used to handle the design of OpenSR—including the administration control panel and the IAT—thus allowing research designers the ability to easily create, customize, and present an IAT for their own purposes. The use of JavaScript and jQuery allows test participants to interact with the IAT without refreshing their Web browser because the scripts are executed on test participants’ computers. Most importantly, JavaScript provides the capability for response times to be recorded with millisecond accuracy. Bootstrap was used for the styling and design of pages
as well as the dynamic features of the application (e.g., the ability for OpenSR to work on any device regardless of the screen resolution).

**HARDWARE AND SOFTWARE CONSIDERATIONS**

The use of S–R tests necessitates examining hardware and software issues pertaining to accurately capturing and recording response times. Advances in most contemporary hardware and software have decreased many of the challenges that might have impacted the use of a program such as OpenSR. We would be remiss, however, if we did not consider and note the potential impact of hardware and software that do not meet certain requirements. Therefore, we provide an overview of three hardware and/or software considerations for researchers conducting S–R tests: variability in operating systems, variability in monitors, and variability in input devices. We also address the important consideration of Internet connectivity during the test.

Preemptive multitasking enables the operating system to interrupt any program that may be running in the background or foreground, which can skew how a program performs operations and when instructions are executed. Interruptions by operating systems are less of an issue nowadays because multicore processors, which are increasingly a standard in computers, enable parallel execution of instruction. In other words, software (e.g., an IAT) can execute more quickly and consistently now on multicore processor systems than when computers had only one processor to handle requests from both the operating systems and the user programs. Variability in testing performance (e.g., recording of response times) due to different operating systems is thus negated in newer computers.

Different types of monitors (e.g., LCD, CRT) have specific mechanisms for “painting the screen” and related delay characteristics for displaying images on the screen. Older CRT monitors, although having a faster refresh rate, paint the screen only one pixel at a time starting from the upper left corner and moving systematically to the lower right. This results in about a 10 ms lag between when the test participant sees the first and last pixels rendered on the screen (Straw, 2008). An LCD monitor paints all the pixels simultaneously but has approximately a 10 ms delay in doing so and a refresh rate of approximately 60 Hz (Straw, 2008). If a program was instructed to leave an image on the screen for a given number of seconds, the image would either be present slightly longer or shorter, depending on when it is initially painted with respect to the 60 Hz clock cycle for refresh rate. Despite differences across types of monitors, human reaction time to visual stimuli is approximately 200 ms (Kosinski, 2013; Ohyanagi & Sengoku, 2010). Therefore, differences in types of monitors should produce negligible variance in response times. Even if a difference in recorded response time based on a factor such as monitor type was present, the results for an individual would be consistent and mathematically averaged out across all trials. For example, a 60 Hz monitor repaints the screen 60 times per second and displays a frame in roughly 17 ms. As a result, a constant variable (e.g., 17 ms) is added to the reaction time of every trial.

Another hardware consideration is the input device and its delay characteristics. Examples of common input devices are the keyboard and the mouse. Keyboard strokes and mouse clicks send a priority interrupt to the operating system, resulting in immediate execution of the command. However, USB-, Bluetooth wireless-, and serial-connected keyboards all have different signaling delay factors from the device to the operating system.
USB has a 20–30-ms delay overall (Peirce, 2009), but this is considered a constant because all responses are being measured on an individual computer during an individual testing session and should be a mathematically constant factor for each participant.

OpenSR is a browser-based tool that requires an Internet connection while a test participant sorts the stimuli (e.g., when the participant presses the left category key, the F, or the right category key, the J). When a test participant starts a test, all necessary data (e.g., the trial and block data) are retrieved from the server and loaded into the test participant’s Web browser. Thereafter, the client-side code running in the participant’s browser displays the retrieved test data. Responses (e.g., pressing F or J) and associated reaction times for each block of trials are recorded locally (i.e., in the test participant’s browser) and the data are sent asynchronously to the server, without interrupting the experience of the test participant. The overall speed of the Internet connection has no impact on recording participant reaction time because response time is measured on the client side, not the server side. If the participant is not connected to the Internet, the server cannot receive the results and the results cannot be saved. It is possible that a participant could start taking a test and subsequently lose Internet connectivity during the test. In this case, when the participant reconnects to the Internet and refreshes the test page, the test will start at the beginning of the block that was active when connectivity was lost. For example, if a participant successfully completed the first and second block but then lost connectivity during the third block, he/she would start at the beginning of the third block when the test page is refreshed after regaining Internet connectivity.

Advances in technology allow personal computers to execute multiple programs without altering the performance of any given task. In addition, regardless of the performance of a test participant’s computer, response time on a single trial is less important than overall difference scores between blocks of trials. In addition, increasing the number of trials in a response-time test such as the IAT can improve the reliability of the test because extraneous factors should be mathematically negated over many trials (Lane et al., 2007). Likewise, any differences based on hardware should be statistically averaged out across all trials on a participant’s test.

**CONCLUSION**

This paper presents OpenSR, a program that facilitates a specific type of S–R test in the field of psychology: the IAT. OpenSR could be adapted to other S–R testing environments to meet researchers’ needs. For example, the OpenSR framework could be used for priming tasks, in which exposure to a stimulus influences subsequent responses to another stimulus. OpenSR currently provides all the functionality for creating a priming experiment using text or images in a designated order specified by a researcher. That is, no additional extensions of the program are required for setting up a priming task. Extended applications of the OpenSR framework could include a wide range of research focuses, such as political science (e.g., for assessing preferences for different political candidates) or Web design (e.g., for assessing ideal placement of text and images on Web sites). In addition, OpenSR could be adapted for use in tasks in any discipline requiring the sorting of text or images into designated categories. Currently, OpenSR is set up to create and administer an IAT. However, the code base was developed with the idea that it could be extended for other uses. Extensions of the
code base for other applications, however, would require programming knowledge, as would the addition of features to the current framework.

OpenSR addresses many of the challenges faced by researchers interested in conducting S–R research via an IAT. Specifically, it provides an open-source Web-based framework with a GUI that can be used for the creation and administration of an IAT, including the ability to easily customize the testing parameters. In addition, it includes capabilities for collecting and exporting data online (as opposed to the need for lab-only settings and software). OpenSR’s user-centered approach thus makes it possible for researchers across disciplines to easily create and administer an IAT without paying expensive licensing fees. OpenSR is available for free download.

ENDNOTES

1. OpenSR can be downloaded for free from https://github.com/justinsvegliato/opensr
2. In an IAT, an error occurs when a stimulus (e.g., a word) is not sorted into the appropriate category. Each stimulus has one correct classification, which is designated in the test configuration phase.

REFERENCES


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IS SCHOOL A BETTER ENVIRONMENT THAN HOME FOR DIGITAL GAME-BASED LEARNING? 
THE CASE OF GRAPHOGAME

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Abstract: This study investigated how the use of an online reading game differs in home and school environments. First and second graders (N = 194) participated in an 8-week training during which they used the reading program GraphoGame either at home or at school under the supervision of parents or teachers. Child participants were recommended by parents and teachers recruited from the list of GraphoGame users, and adults decided whether the training took place at home or at school. We measured the frequency and duration of playing, children’s engagement, development of reading skill and reading interest, and adult supportive involvement. The results revealed that children who played GraphoGame at school showed higher engagement and used it more frequently than players at home. Although teachers were more involved in the children’s playing than were parents, only parental involvement was significantly associated with a child’s engagement during training and the child’s learning outcomes.

Keywords: digital game-based learning, learning environment, GraphoGame, motivation, engagement, parental involvement.

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INTRODUCTION

Research has shown that digital games can enhance children’s learning, with positive effects found, for example, in the development of reading skills (e.g., Heikkilä, Aro, Näärhi, Westerholm, & Ahonen, 2013; Magnan & Ecalle, 2006; Saine, Lerkkanen, Ahonen, Tolvanen, & Lyytinen, 2010, 2011) and mathematical skills (e.g., Miller & Robertson, 2011; Shin, Sutherland, Norris, & Soloway, 2012). Additionally, children usually are very eager to use digital learning games (e.g., Rosas et al., 2003; Tüzün, Yılmaz-Soylu, Karakuş, İnal, & Kızılkaya, 2009). However, most of the earlier research concerning children’s use of digital learning games has been conducted in the school environment, with fewer studies addressing the benefits of home use of digital learning games. Yet learning through educational games at home could be a valuable supplement to school instruction, especially for children who lag behind their peers in the classroom. Games could encourage these children to practice their skills during their leisure time and engage them more effectively in learning as compared to traditional paper-and-pencil homework assigned by the teacher.

The aim of this study is to compare the school and the home as learning environments for digital game-based learning in terms of the frequency and amount of game playing, the children’s engagement, the learning achieved, and the level of parent or teacher involvement. Few studies have investigated how the use of the same educational game varies in different learning environments, although this information could be potentially useful for game design. For example, parents, teachers, and children may have different expectations of the game in different circumstances, which in turn may affect the way the game is used and experienced. Additionally, many digital learning games are designed for independent use, but young children in particular may benefit from adult involvement in computer-based learning (Klein, Nir-Gale, & Darom, 2000; Schmid, Miodrag, & Di Francesco, 2008; Tzuriel & Shamir, 2002). In this study, we address this issue by exploring how parents and teachers are involved in children’s use of a learning game and whether their involvement is associated with the children’s playing time, engagement, and learning gains.

Educational Use of Computers in Homes and Schools

Earlier studies suggest that home computers typically are used for entertainment, especially for playing games (Harris, Straker, & Pollock, 2013; Hofferth, 2010; Kerawalla & Crook, 2002; Lewin, 2004; Selwyn, Potter, & Cranmer, 2009; Valentine, Marsh, & Pattie, 2005; Vekiri, 2010) or for Internet access, email correspondence, and social media use (Harris et al., 2013; Selwyn et al., 2009; Valentine et al., 2005). School computers, on the other hand, commonly are used for writing and word processing (Harris et al., 2013; Kent & Facer, 2004; Selwyn et al., 2009), learning via educational software (Harris et al., 2013; Kent & Facer, 2004), or looking for information on the Internet (Kent & Facer, 2004).

Although the educational use of computers is more typical at school than at home, home computers also are used for learning activities. Valentine et al. (2005) found that, among 6- to 7-year-old children, 51% of girls and 42% of boys used educational computer games at home. In Vekiri’s (2010) study, approximately one-third of Grade 5 and 6 students from high- to middle-socioeconomic status families used computers for educational activities outside school, such as
within the drill and practice method and for learning new content. Leisure time use of computers for education was less common among children of low-socioeconomic-status families.

However, in comparing other activities with the home computer, the use of educational software seems to be quite marginal. Kerawalla and Crook (2002) observed that approximately 10% of children’s time on the home computer was spent using educational software, even though home computers were often acquired for educational purposes. In a later study, Kerawalla and Crook (2005) gave educational CD-ROMS to 32 families with children aged 7 to 11 and logged the usage of the software on the family computer for 11 weeks. They found that, despite initial enthusiasm, the use of the educational software quickly declined from 55% of the total time spent on the home computer during the first week to 10–25% during the following weeks. Holmes (2011) also observed low enthusiasm for the use of learning games on the home computer. In his study, 8- to 10-year-old struggling readers (N = 6) used educational games that were designed to support the development of reading skills. Although the children said they enjoyed the games and believed them to be helpful, they tended to lose interest in the games after the novelty had worn off. Moreover, the children often played games that were not appropriate for their skill level, which decreased their motivation. Finally, all children preferred other activities at home over playing the educational games.

In informal learning settings such as homes, children typically have several opportunities for choice, for example, concerning when and how to use the computer and which activities to engage in. In more formal environments such as schools, there are more restrictions (Barendregt & Bekker, 2011; Harris et al., 2013; Lewin, 2004; Valentine et al., 2005). Based on earlier research, it seems that educational computer games are not able to compete with other activities when the child has the freedom to choose which activities to engage in. Barendregt and Bekker (2011) studied an English-vocabulary-building computer game for Dutch children and found that the children least interested in using the game were those who attended a school that allowed the pupils to choose freely in which activities to engage. The children at the two other schools, where only a limited choice or no choice in learning activities was offered, were more eager to use the game. All children in the study also had an opportunity to play the game at home, but only a few children did this.

According to self-determination theory (see, e.g., Ryan & Deci, 2002), ideal learning environments are those that satisfy the three basic psychological needs of competence, autonomy, and relatedness. In learning environments such as these, the child can experience intrinsic motivation, a situation in which an individual is involved in an activity in the absence of any apparent external contingency and finds the activity itself rewarding (Deci & Ryan, 1980). Children learning in these environments are highly engaged in the learning activity, appear to be attentive and persistent, and show positive emotions such as interest and enjoyment as well (Reeve, 2002). According to Niemiec and Ryan (2009), competence can be supported in the school environment through optimally challenging learning activities and encouraging feedback. Autonomy can be supported, for example, by emphasizing students’ perceptions of having choice. Relatedness is experienced when the students feel that the teacher genuinely likes, respects, and values the students. Well-designed digital game-based environments can satisfy these three needs (Ryan, Rigby, & Przybylski, 2006).

In the home environment, children typically are used to having a choice of activities. Yet, in the case of educational games, children may not be permitted to decide which games to play or when, leading to situations that can be detrimental to children’s intrinsic motivation, according to
self-determination theory (Wouters, van Nimwegen, van Oostendorp, & van der Spek, 2013). Moreover, games that are designed to aid children with learning difficulties need to be used regularly to produce the desired outcomes. Yet, teachers and parents often are the ones who decide which games the child should use, when, and for how long. Wouters et al. (2013) speculated that this, in addition to problems in game design, could explain why educational games are not more motivating than traditional instruction methods, according to their recent meta-analysis.

Nevertheless, there is evidence that the educational use of computers at home may have a positive effect on children’s attainments in school (Hofferth, 2010; Valentine et al., 2005) and that it may increase the motivation and self-esteem of low achievers (Valentine et al., 2005). Some studies suggest that using specific educational software at home might result in more learning gains than using the same software at school. Ben-Zadok, Leiba, and Nachmias (2010) compared the learning behaviors of elementary school students who used an online science learning environment either at home or at school. Log file analysis revealed that students learning at home took more time to complete the learning module, worked at a slower pace, and scored higher on an achievement test than students learning at school. In another study, Magnan and Ecalle (2006, Experiment 3) compared the school use and home use of a computer game that developed word recognition skills in children with dyslexia and found improvement only in the home training group. According to the researchers, this could be because the children training at home were experienced computer users and because the parents were highly motivated to participate in the study and support their children’s training. The children who used the game at school had no previous experience with computers, and their teachers were not involved in the training; the at-school use was overseen by a neutral experimenter between lessons.

**Adult Involvement in Digital Game-Based Learning**

Research has shown that adult involvement in children’s use of computers is typically low, especially at home. Harris et al. (2013) found that children between ages 6 and 16 typically used computers alone at home (58% of participants), although using them with a sibling or a friend was also quite common (32.3%). Only 11.3% of children reported that their parents were usually with them during computer use. In contrast, most participants (69.7%) reported being with friends while using a computer at school, and 25.9% reported usually being with teachers. A recent survey conducted in Finland (Suoninen, 2014) supports those at-home findings, revealing that 7- to 8-year-old children typically use digital games alone (42% of the children) or with siblings or friends (42%). A parent or other adult was the most typical companion for only 14% of the children, although about one-third of parents played digital games with their children at least once a week. Parents were less familiar with the games their children played than, for example, the television shows that their children liked to watch, and most of the parents talked about the games only occasionally or rarely with their children.

Similarly, Kerawalla and Crook (2005) found that children typically used educational software on their own at home. They suggested that this may be because the programs do not enable the parents to actively engage in the learning process or help parents understand how these programs could support children’s learning at school. Parents may not feel computer-competent enough to provide support for their children’s learning, and teachers may hesitate to give parents advice on how to use computers for educational purposes at home (Valentine et
Lack of parental involvement may also be related to the differences in the cultural contexts of the home and the school, which make it difficult to integrate educational use of computers into home life (Kerawalla & Crook, 2002). In schools, computer use typically is orchestrated by teachers, often in accordance with the underlying curriculum. Parents, on the other hand, may be reluctant to organize formal educational activities on the home computer and, even if they are not, their children may not be willing to accept instruction from adults who they do not associate with a teacher’s role (Kerawalla & Crook, 2002). In a later study, Kerawalla et al. (2007) used tablet computers to make the link between learning at home and at school more transparent. In this way, the same learning materials were available both at school and at home, and parents could see how homework was related to classwork. The system was well received by both the children and their families, and the rate of use of the educational games was much higher than in previous studies.

A study conducted by Klein et al. (2000) suggested that active support from adults during the use of educational software could increase children’s learning and engagement. They trained teachers to mediate the learning of 5- to 6-year-old children during the use of an educational game or an application that teaches children to program. The mediation practices included expressing meaning and affect, expanding learning experiences, regulating the child’s behavior, and generally encouraging the child. The results suggested that adult mediation produced significant gains in abstract thinking, planning, vocabulary, visuo-motor coordination, and responsiveness. Providing only technical assistance or being available to answer the child’s questions did not seem to help children’s cognitive development. Similarly, Tzuriel and Shamir (2002) found that 5-year-old children’s performances in a task that dynamically assessed a child’s cognitive ability improved when their performance was mediated both by a computer program and an examiner rather than by either the computer or examiner alone. The study clearly showed that the computer alone could not replace the role of a human mediator. Schmid et al. (2008) also observed that an adult tutor played an important role in the child’s interaction with a computer program that taught reading and writing skills. The tutor guided and motivated the child, particularly when the child encountered difficulties, and provided cognitive support to help the child progress or to sustain the child’s interest.

The **GraphoGame Learning Environment**

GraphoGame¹ (in Finnish, *Ekapeli*) is a digital, Web-based learning environment designed to support children’s reading acquisition. The development of the GraphoGame at the University of Jyväskylä, Finland, is based on the findings of the Jyväskylä Longitudinal Study of Dyslexia (see, e.g., Lyttinen et al., 2006). This research suggested that future reading problems often stem from difficulties in the perceptual differentiation of the manifestations of phonemes that are acoustically close and the consequent problems in learning the connections between letters and sounds (e.g., Lyttinen, Erskine, Kujala, Ojanen, & Richardson, 2009). GraphoGame provides intensive training in letter–sound connections that has been shown to help children overcome these difficulties (for a recent review of results, see Richardson & Lyttinen, 2014).

In the basic letter–sound connection task of GraphoGame, the player hears a sound while a number of letters (target and distracters) appear on the screen (Figure 1). The player is expected
Figure 1. A basic training task of GraphoGame. (The player hears a speech sound and is expected to select the corresponding letter from the alternatives shown on the screen.)

to select the letter corresponding to the spoken sound. The game provides immediate feedback: Correct answers are acknowledged; if an incorrect answer was selected, the correct alternative is highlighted before the next trial is presented. To develop reading skills in a language with a transparent writing system (such as Finnish), the game begins with connections between single sounds and letters. Once the child has mastered this skill, the game advances to developing the connections between spoken and written syllables and words. Because of the adaptive level of difficulty, the game remains optimally challenging regardless of the child’s skill level at each stage of his/her playing and, hence, supports a child’s sense of competence. The GraphoGame interface is simple and easy to use, and most children are able to play the game without assistance from adults. With parental consent, the players’ usage data are stored on the GraphoGame Web server. These data can be used by parents and teachers who want to observe how their students or children are performing in the game, as well as by researchers who are interested in studying the learning processes of the players. For a more detailed theoretical and methodological background and description of GraphoGame, see Richardson and Lyytinen (2014).

The GraphoGame version used in this study was originally developed for a study comparing the effects of game features on children’s engagement and learning (Ronimus, Kujala, Tolvanen, & Lyytinen, 2014). The game is aimed at Finnish-speaking children and it consists of tasks in which the learner connects written language units to those of spoken language units, ranging from connecting single sounds to letters and then connecting longer spoken words and pseudowords to their written counterparts. The difficulty of each task is determined by the child’s responses to previous tasks, according to a Bayesian-probability-model-based adaptation technique developed by Kujala, Richardson, and Lyytinen (2010). The game version includes a reward system: After connecting 20 speech sounds to their written counterparts, the player receives a game token. After collecting five tokens, the player
gains access to a reward area of the game that offers optional playing levels. These reward games also develop reading skills, but the type and visual appearance of the tasks differ from those of the basic game. Each reward level costs five tokens; the return to the basic game allows the learner to earn more tokens. The reward games offer increased choice in the game and, as a consequence, improve the motivational appeal of the game.

Earlier Finnish studies suggest that GraphoGame can effectively help young children who need support in reading acquisition (e.g., Lyytinen, Ronimus, Alanko, Poikkeus, & Taanila, 2007; Lyytinen et al., 2009). Saine et al. (2011) found that struggling 7-year-old readers who received a remedial training program that included GraphoGame sessions achieved higher gains in reading and spelling than children who participated in a similar program without GraphoGame sessions. In another study, a shorter and less intensive 6-week intervention with GraphoGame accelerated 7-year-old children’s letter naming skills, but no effect on reading was observed (Hintikka, Aro, & Lyytinen, 2005). Lovio, Halttunen, Lyytinen, Näätänen, and Kujala (2012) found that a short but intensive 3-week intervention improved 6-year-old children’s phonological awareness and writing skills. The electroencephalogram (EEG) data collected in the study suggest that GraphoGame use also may be beneficial in modulating the neural basis of phonetic discrimination. Heikkilä et al. (2013) found that a brief intervention with GraphoGame increased children’s reading speed of the syllables encountered in the game.

The previous studies focused on the basic reading skills of Finnish-speaking students. Meanwhile, Kyle, Kujala, Richardson, Lyytinen, and Goswami (2013) studied the effects of two English versions of GraphoGame. The GraphoGame Phoneme version progresses from small to large units of language. It first teaches the players all the phonemes (individual sounds) in connection with prototypical graphemes (letters) before moving on to consonant-vowel and vowel-consonant segments and eventually progressing to words. In the GraphoGame Rime version, however, much of the training focuses on larger rime units (i.e., the spelling units for rhyming sounds). A small set of single sounds with the corresponding written units are introduced and immediately used for presenting rime units and words containing these rime units. In Kyle et al.’s study, 6- to 7-year-old children with poor reading skills received approximately 11 hours of either GraphoGame Rime or GraphoGame Phoneme training over 12 weeks as a supplement to normal classroom literacy instruction. Both interventions led to gains in reading, spelling, and phonological skills in comparison to an untreated control group. Furthermore, the gains were maintained at a 4-month follow-up assessment. The GraphoGame Rime version produced slightly larger gains in some of the reading and phonological tasks.

The Present Study

Although GraphoGame has been widely used at homes in Finland for several years, most previous studies have investigated GraphoGame use in formal learning environments, such as schools and kindergartens. Home use of GraphoGame offers several potential benefits. First, the extra training provided at home may help at-risk children catch up with their peers before they start to view themselves as slow learners, a perception that may result in negative consequences for their self-concept and learning motivation (Aunola, Leskinen, Onatsu-Arvilommi, & Nurmi, 2002; Chapman & Tunmer, 2003; Morgan, Fuchs, Compton, Cordray, & Fuchs, 2008). Additionally, school days, particularly for younger students, are short in
Finland, which is why many teachers find it difficult to allocate time for GraphoGame sessions. Some teachers also may struggle to individualize classroom education so that only those with poor reading skills participate in the GraphoGame sessions, while others receive typical instruction. Finally, using GraphoGame at home also could increase parents’ involvement in their children’s education.

To the authors’ knowledge, no prior studies have been conducted that compare the use of the same educational game in both the home and school environments while simultaneously assessing the child’s engagement, learning gains, and parent and teacher involvement in the training. However, previous research does suggest that using home computers for learning is not a popular activity among children and that parents do not seem to take an active role in their children’s learning via the home computer. Therefore, the primary purpose of this study is to investigate three important concepts: (a) how learning with GraphoGame is accomplished at home in comparison to in school, (b) if there are differences in children’s engagement and learning outcomes between the two environments, and (c) to what extent parents and teachers get involved in the training.

The study was conducted in Finnish children’s homes and schools. The participating children were identified with the help of parents and teachers who were already registered users of GraphoGame and had previously used the game with their older children or former pupils. They were asked if they knew first-grade children who needed support in their reading acquisition, and those who responded affirmatively were recruited into the study, along with the children they identified. The training took place either at home or at school, usually depending on whether a parent or a teacher had enrolled the child into the study. The adult participants were free to decide what time of the day the GraphoGame sessions would take place and for how long and how frequently the children would play, although they were advised that the game should be used regularly. The data about the usage were collected via the Internet and saved on the GraphoGame server from where they were retrieved for the analysis.

The study was framed by four primary research questions. Each of the questions is explained more fully here.

1. Does the frequency and duration of GraphoGame usage differ between home and school settings when parents and teachers have the freedom to choose the environment?

   Based on earlier studies, we expected that GraphoGame usage would be more frequent at school than at home, possibly because the use of an educational game may be easier to integrate into other learning activities at school, as opposed to into leisure-time activities at home. Additionally, children in school are used to performing activities chosen by teachers, whereas children are accustomed to more freedom in what to do at home and may resist activities that their parents choose for them.

2. Do children’s engagement with the GraphoGame activities differ between home and school?

   We expected that children using GraphoGame at school would show a higher level of engagement in playing because earlier studies have suggested that the use of educational games is not common at home; this may be because children do not find the learning games as engaging as other activities at home. In this study, we addressed both behavioral and emotional aspects of engagement (Reeve, 2002) by measuring the child’s concentration and enjoyment during GraphoGame use. However, self-report measures are often problematic with young children because
children’s cognitive skills are still developing (Fulmer & Frijters, 2009). Therefore, we also used the adults’ evaluations of the children’s enjoyment and concentration in addition to the self-reports.

3. Do children’s reading skills and reading interest develop differently depending on whether the GraphoGame training occurs at home or at school?

If the results to Questions 1 and 2 suggest that school-based learning with GraphoGame is more frequent and engaging than home-based learning, one might conclude that children’s skill and interest in reading activities would develop more among those learning at school. Many earlier studies suggest that time on task and engagement positively affect students’ learning (see a review by Cotton, 1989) and that high reading skills and interest in reading often go hand in hand (Frijters, Barron, & Brunello, 2000; Morgan & Fuchs, 2007; Wigfield, Wilde, Baker, Fernandez-Fein, & Scher, 1996).

4. To what extent do parents and teachers get involved in children’s GraphoGame usage, and is their involvement associated with children’s engagement and learning with GraphoGame?

Earlier studies suggest that parents typically do not get involved in their children’s computer activities at home, and thus we expected that the parents in our study would be less involved in children’s use of GraphoGame than the teachers. Prior studies also suggest that adult involvement can help the child perform better and gain more from computer-based learning tasks. However, GraphoGame is designed for a child’s independent use and with an adaptive level of difficulty, so it is unclear if adult involvement in the form of helping the child to solve the learning tasks is meaningful or even desirable. The main role of the adult more likely is to recommend when the child should play and for how long, as well as provide encouragement and positive feedback to sustain the child’s engagement in the training. In this study, we measure these two aspects (control over playing times and encouragement) in addition to investigating the adult’s participation in the training, that is, to what extent the adult is present during the sessions. Adult presence during the sessions may support the child’s sense of relatedness and, as a consequence, may increase the child’s engagement in training.

METHOD

Participants

The participants were recruited from the mailing list of GraphoGame users. Parents and teachers were sent an e-mail describing the study and were asked to participate if they had a child or a pupil who either was unable to read or needed support in reading acquisition. The adult GraphoGame registrants who indicated that they were interested in participating were sent further information about the study as well as a consent form to be completed by the child’s parent. The consent form included questions about the child, such as birth date and prior use of GraphoGame and other digital games. Only children whose parents or teacher could provide computer access that met the technical requirements of GraphoGame were able to participate in the study.
All children whose parents returned a signed affirmative consent form and who played the game at least once at home or at school during the study period were included in the study analysis \((N = 194)\). More boys \((n = 118, 60.8\%)\) than girls \((n = 76)\) are in the sample, which is probably because reading problems are typically more common among boys than girls (e.g., Rutter et al., 2004). The data show that 101 children played the game at home under the supervision of 99 parents and 93 children played at school, supervised by 27 teachers. Boys and girls were evenly represented in both learning environments. Parents typically oversaw one child’s training, but the number of children playing under the guidance of one teacher ranged from 1 to 10 \((M = 3.44)\). The hierarchical nature of data was not taken into account in the analyses because the mean number of pupils per teacher was relatively low, and almost half of the teachers \((13/27)\) supervised only one or two children.

The mean age of the participants was 7.39 years (range 6.82–10.01). Most children spoke only Finnish \((94.8\%)\), but 5.2% also spoke a second language. Most of the children \((95.9\%)\) were in the first grade, but some second graders who were struggling at reading acquisition were also accepted in the study. Some of the children \((20.1\%)\) attended a special education class or received instruction in a small group, typically because of learning or behavior-related problems. Half of the children \((50.8\%)\) had already played GraphoGame before this study. Previous experience was more common among at-home players \((71.4\%)\) than at-school players \((29.0\%)\), probably because the majority of the parents who were registered as GraphoGame users already had some version of the game installed on the home computer. However, the game version used in this study was novel to all participants. According to the parents, nearly all children in the study \((97.9\%)\) played video or computer games during their leisure time.

Parental reports also indicated that 27.9% of the children had experienced some problems in their development (beyond struggling with reading acquisition). The most common problems were in language development \((14.4\%)\), motor skills development \((5.9\%)\), and attention \((4.3\%)\). These numbers were compared with those of registered players of the current first-grade version of GraphoGame who were of similar age and whose parents had responded to the optional background information survey about their child \((N = 5,692)\). Boys were overrepresented also in this larger sample \((56.5\%)\). The parents in the larger sample reported that 21.9% of the children had experienced problems in language development, and 16.1% in some other areas, most commonly in motor skills \((6.7\%)\), memory and naming \((6.2\%)\), and attention \((5.7\%)\). We should note that whereas the present study asked the parents to give a free-form description of the child’s developmental problems, specific questions were used in the GraphoGame background information survey, which may affect the results slightly. Nevertheless, the child participants in this study were considered to be fairly representative of the children who typically use the first-grade version of GraphoGame in Finland.

**Procedure**

At the beginning of the study, the parents and teachers were sent a link for downloading GraphoGame and instructions for carrying out the training. Parents and teachers were told that the training period was 8 weeks long and that the children should play at least two or three times a week, preferably more often, for approximately 10 to 15 minutes at a time. They were also reminded that using the game should be voluntary for the children: A reluctant child
should not be pushed into playing the game because this could have negative consequences for a child’s motivation to learn to read.

When the participating child first launched the game, the system presented pretest tasks that evaluated the child’s reading skills and interest in reading and writing. Once these were completed, the game continued with the training tasks. Eight weeks after the first session, the game automatically presented the child with the posttest tasks that included the same items as in the pretest. When the posttest was completed, the game was locked and could not be used further.

Ten weeks after the first play session, the parents and teachers who conducted the training were sent an online questionnaire in which they were asked to evaluate the child’s experiences with GraphoGame. The response rate to the questionnaire was 86%, with a higher response from the teachers. Parents of the school players were sent a shorter questionnaire that included questions about their children’s interest in reading and writing. The response rate to this questionnaire was 56%.

**Measures**

**Engagement**

Children’s enjoyment of GraphoGame and concentration during playing were measured by a survey that was presented within the game when the child finished the play session and pressed the Exit button. A female voice first asked the child how much he or she had enjoyed playing the game and then how easy it had been to concentrate on playing that time. After each question, five faces, ranging from a big smile to a big frown, appeared on the screen, and the child rated his/her enjoyment/concentration by clicking one of the faces. A previous study suggests little change over time in children’s ratings of their enjoyment of playing GraphoGame (Ronimus et al., 2014), which is why we use a mean of all ratings given during the training as the measure of each child’s overall enjoyment/concentration.

Parents and teachers were asked to evaluate the child’s motivation and concentration during GraphoGame play via two questions in the end-of-training questionnaire. Motivation was measured by “How eagerly did the child play GraphoGame during the study?” and concentration by “How well did the child concentrate while playing GraphoGame?” The parents and teachers answered using a 5-point scale, ranging from very eagerly/well to very reluctantly/poorly. Parents and teachers also were asked if there had been any nontechnical problems that had prevented the child using the game as often as was intended. If so, they were asked to give a free-form description of the problem. Each child was rated either by a teacher or parent. The teachers who were in charge of more than one child’s playing, therefore, completed multiple forms.

For the analysis, the four variables (i.e., the child’s self-rated enjoyment and concentration and adult-rated motivation and concentration) were combined to form one variable measuring the child’s general engagement in GraphoGame training. Cronbach’s alpha for this measure of engagement was .72.

**Interest in Reading and Writing**

The children’s interest in reading and writing was evaluated both by the children themselves and by their parents. Children rated their interest in reading- and writing-related school tasks by
responding to two questions presented in an in-game survey as a part of the pre- and posttest. The survey was similar to the one used to evaluate enjoyment of playing. The questions were presented within the pretest and posttest. Parents were also asked to evaluate how interested their children were in reading and writing via two 5-point-scale questions that were included in the consent form at the beginning of the study as well as in the online questionnaire at the end of the study. Therefore, four different interest ratings were collected (child-rated reading interest, child-rated writing interest, parent-rated reading interest, parent-rated writing interest) both at the beginning and end of the training. Because of relatively low correlations between the ratings, all eight ratings were treated as separate variables in the analyses.

**Reading Skill**

Reading skill was measured using two in-game tasks that were presented in the pretest and posttest. The first task involved real words and the second task presented pseudowords. In both tasks, the player heard 44 increasingly difficult words, one at a time, and was asked to select the corresponding written word from the six alternatives shown on the screen. Because the scores of the two tasks were highly correlated, the mean score was used in the analysis. Cronbach’s alpha was .89 for the pretraining reading test score and .87 for the posttraining reading test score. Prior studies of GraphoGame reading tests have found a strong correlation with those of traditional reading tests administered by a researcher (Heinola, Latvala, Heikkilä, & Lyytinen, 2010).

**Adult Involvement**

Adult involvement was measured using four questions that were included in the end-of-training questionnaire. Adult participation during the GraphoGame sessions was measured with a 5-point scale (1 = child played alone, 2 = occasional adult visits in the room where the game was used, 3 = adult present in the room, 4 = adult present in the room and actively observing the child, providing help if needed, 5 = adult actively provided help). Teachers and parents also were asked to evaluate how often they provided positive feedback and encouragement to the child during training (5-point scale, ranging from constantly to never) and were asked if the child received rewards for playing the game (yes/no). If rewards were given, a free-form description of the type of reward was solicited. Finally, teachers and parents were asked who usually initiated the play sessions (child alone/adult alone/together) and who usually decided how long the child should play at a time (child alone/adult alone/together). Initiating a play session together was described as the adult suggesting a play session but the child making the final decision. Making the decision about the play session duration together was described as the adult setting the duration, but allowing the child to stop a bit earlier or to continue a bit longer if the child requested so.

**RESULTS**

**GraphoGame Usage and Engagement at Home Versus at School**

Children’s playing start and end times and numbers of play sessions were retrieved from the GraphoGame online server where they had been automatically recorded whenever the game
was used. The analysis of the data revealed that there were clear differences in the duration and frequency of GraphoGame usage between at-home and at-school players. The results are reported in Table 1, along with Cohen’s $d$ effect sizes. The average total of playing time by the children playing at school was 362 minutes over 8 weeks, whereas, at home, it was significantly lower, 198 minutes ($p < .001$). Additionally, the mean number of play sessions was clearly higher among school players than among home players (22 vs. 13, $p < .001$). Children’s engagement in playing GraphoGame, as evaluated both by the children themselves and by the adults observing children’s playing, was higher at school than at home ($p < .001$, see Table 1).

When asked whether the game was used less frequently than intended during the training period, the teachers of 9 children playing at school agreed (the number of children represents 10.6% of the at-school players whose teachers responded to the end-of-training questionnaire). According to the teachers’ free-form answers, the most common reason for infrequent playing was that the game was too difficult (4 children). In contrast, the parents of 49 children (63.6% of the at-home players whose parents responded to the questionnaire) reported that the game had been used less frequently than intended. The most common explanation was the child’s unwillingness to play (33.3% of the at-home players) because, for example, of tiredness after school or poor motivation. Other common explanations for infrequent playing were that the game was too repetitive or dull (18.8%), the game was too difficult (12.5%), the child had learned to read (12.5%), and/or there was a lack of time (10.4%).

Table 1. Playing Time, Engagement, Reading, and Adult Involvement in School and Home Environments.

<table>
<thead>
<tr>
<th>Location</th>
<th>n</th>
<th>M</th>
<th>SD</th>
<th>t</th>
<th>df</th>
<th>p</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total playing time (min)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>93</td>
<td>361.76</td>
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<td>6.24</td>
<td>139.37</td>
<td>&lt;.001</td>
<td>0.91</td>
</tr>
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<td></td>
</tr>
<tr>
<td>Number of sessions</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td>4.52</td>
<td>164</td>
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<td>Reading pretest</td>
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<tr>
<td>Home</td>
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<td>Reading posttest</td>
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</tr>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Participation</td>
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<td></td>
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<td></td>
</tr>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>School</td>
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<td>3.12</td>
<td>1.17</td>
<td>-1.51</td>
<td>157.63</td>
<td>.133</td>
<td>0.23</td>
</tr>
<tr>
<td>Home</td>
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<td>3.36</td>
<td>0.89</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>Control of playing times</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>School</td>
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<td>0.87</td>
<td>2.83</td>
<td>151.69</td>
<td>.005</td>
<td>0.45</td>
</tr>
<tr>
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<td>2.24</td>
<td>1.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Reading Performance

There was a clear improvement in the reading scores for all children from pretest ($M = 13.93$, $SD = 11.24$) to posttest ($M = 20.50$, $SD = 12.26$), $F(1, 118) = 64.23$, $\eta^2_p = .35$, $p < .001$. According to repeated measures ANOVA, at-home players improved their scores more than at-school players, $F(1, 117) = 4.19$, $\eta^2_p = .04$, $p = .043$. There was also a difference in the level of children’s performance, with home players scoring higher than school players both in the pretest and posttest (see Table 1).

Interest in Reading and Writing

Children’s parents were asked to evaluate their children’s interest in reading and writing at the beginning and end of the training. Children themselves also rated how much they liked reading- and writing-related tasks in the pretest and posttest. The number of respondents was somewhat lower at the end of training because (a) some children had stopped using the game by then and (b) a significant minority of parents, especially those of at-school players, did not respond to the postraining survey, possibly because they were not actively involved in the study.

The mean ratings are reported in Table 2. According to the parents’ evaluation, at-school players seemed to be more interested in reading and writing activities than at-home players, apart

| Table 2. Children’s Reading and Writing Interest in the Beginning and End of The Training as Evaluated by Parents and Children. |
|-----------------|-----|-----|-----|-----|-----|-----|-----|
| Time | Location | N  | M   | SD  | t   | df  | p   |
| Reading interest (parent-evaluated) | Pre | School | 89 | 3.46 | 1.06 | 0.23 | 188 | .817 | 0.03 |
| | Home | 101 | 3.43 | 1.02 | | | |
| | Post | School | 52 | 3.81 | 1.01 | 2.15 | 131 | .033 | 0.38 |
| | Home | 81 | 3.41 | 1.07 | | | |
| Writing interest (parent-evaluated) | Pre | School | 89 | 3.61 | 0.95 | 2.20 | 187 | .029 | 0.32 |
| | Home | 100 | 3.32 | 0.84 | | | |
| | Post | School | 52 | 3.69 | 0.92 | 3.02 | 131 | .003 | 0.53 |
| | Home | 81 | 3.19 | 0.96 | | | |
| Reading interest (child-evaluated) | Pre | School | 91 | 4.30 | 1.14 | 2.37 | 185.37 | .019 | 0.34 |
| | Home | 99 | 3.86 | 1.40 | | | |
| | Post | School | 65 | 3.94 | 1.53 | 0.58 | 125 | .564 | 0.10 |
| | Home | 62 | 3.79 | 1.35 | | | |
| Writing interest (child-evaluated) | Pre | School | 91 | 4.03 | 1.32 | 0.61 | 188 | .543 | 0.09 |
| | Home | 99 | 3.92 | 1.25 | | | |
| | Post | School | 65 | 3.82 | 1.36 | 0.78 | 125 | .439 | 0.14 |
| | Home | 62 | 3.63 | 1.35 | | | |
from reading interest at the beginning of the training in which no significant difference was observed. In contrast, according to the children’s pretraining ratings, at-school players were more interested in reading than at-home players, but there were no significant differences between the two groups in posttraining reading interest or writing interest self-assessments.

Repeated measures analysis of variance was used to examine if there was any change in reading or writing interest from the beginning to the end of the training and, if so, whether the magnitude or direction of change differed between at-home and at-school players. The analysis found a marginally significant interaction between the learning environment and parent-rated reading interest, \( F(1, 129) = 3.30, \eta_p^2 = .03, p = .071 \). According to the parents’ responses, there was an improvement in at-school players’ reading interest, \( F(1, 49) = 4.12, \eta_p^2 = .08, p = .048 \), whereas at-home players’ interest did not change significantly, \( F(1, 80) = .15, \eta_p^2 = .00, p = .697 \). No significant changes were found in parent-rated writing interest or in the child-rated reading or writing interests.

The Role of the Learning Environment

Because the data indicated differences between at-home and at-school players regarding prior GraphoGame experience, reading test scores, child-rated reading interest, and parent-rated writing interest at the beginning of the study, we decided to investigate whether the learning environment still would explain some of the variance in total playing time, engagement, and posttraining reading score after controlling for these variables. We used hierarchical regression analysis to investigate this. The four variables in which the differences were observed were entered in the model on the first step, and the learning environment was entered on the second step. The summary of the results is reported in Table 3.

Regarding total playing time, both pretest reading skill and earlier experience of GraphoGame were significant predictors so that the children with higher pretest reading scores and the children who had played GraphoGame before this study tended to play the game less. However, when the learning environment was entered into the model, this became the only significant predictor, with at-school players playing more than at-home players. Approximately 20% of the variance in total playing time could be explained by these five predictors.

Regarding engagement, earlier experience of GraphoGame and self-reported interest in reading were significant predictors at the first step, with those new to the game and those expressing a higher interest in reading showing higher engagement. When the learning environment was entered into the model, the child’s self-reported reading interest remained a significant predictor. In addition, the learning environment was significantly associated with engagement, with at-school players showing higher engagement. The five predictors explained approximately 24% of the variance in engagement.

The strongest predictor of reading posttest score was, not surprisingly, the reading pretest score. However, the learning environment also was significantly associated with reading posttest score, with at-home players particularly showing higher reading skill at the end of the study. The five predictors explained approximately 58% of the variance in posttest reading score.
Table 3. Hierarchical Regression Model with Reading Pretest, GraphoGame Experience, Writing and Reading Interests, and Learning Environment as Predictors of Total Playing Time, Engagement, and Reading Posttest.

<table>
<thead>
<tr>
<th></th>
<th>Step 1</th>
<th>Step 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>SE B</td>
</tr>
<tr>
<td>Playing time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading pretest</td>
<td>-3.13</td>
<td>1.35</td>
</tr>
<tr>
<td>GG experience</td>
<td>-71.58</td>
<td>30.04</td>
</tr>
<tr>
<td>Writing interest (p)</td>
<td>-5.16</td>
<td>16.59</td>
</tr>
<tr>
<td>Reading interest (c)</td>
<td>17.46</td>
<td>10.86</td>
</tr>
<tr>
<td>Learning environment</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>R²</td>
<td>.09</td>
<td></td>
</tr>
<tr>
<td>Engagement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading pretest</td>
<td>0.00</td>
<td>0.04</td>
</tr>
<tr>
<td>GG experience</td>
<td>-0.26</td>
<td>0.09</td>
</tr>
<tr>
<td>Writing interest (p)</td>
<td>0.07</td>
<td>0.05</td>
</tr>
<tr>
<td>Reading interest (c)</td>
<td>0.12</td>
<td>0.03</td>
</tr>
<tr>
<td>Learning environment</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>R²</td>
<td>.19</td>
<td></td>
</tr>
<tr>
<td>Reading posttest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading pretest</td>
<td>0.82</td>
<td>0.07</td>
</tr>
<tr>
<td>GG experience</td>
<td>-0.62</td>
<td>1.75</td>
</tr>
<tr>
<td>Writing interest (p)</td>
<td>-1.23</td>
<td>0.96</td>
</tr>
<tr>
<td>Reading interest (c)</td>
<td>-0.98</td>
<td>0.61</td>
</tr>
<tr>
<td>Learning environment</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>R²</td>
<td>.55</td>
<td></td>
</tr>
</tbody>
</table>

Note. p = parent-evaluated, c = child-evaluated

Parent and Teacher Involvement in GraphoGame Play

Teachers participated in the children’s playing more actively than parents (p = .001; see Table 1). Many teachers actively observed the child’s playing and provided help when needed (39.0% of the at-school players) or were present in the same room (37.8%). At home, the results show that the child typically was playing in a separate room and the parent occasionally visited (42.5% of the at-home players), although actively observing the child’s playing and providing help when needed was also quite common (31.2%). There was no significant difference in the frequency of receiving encouragement between at-home and at-school players (p = .133).

The use of rewards to motivate the children to play was rare, with only 11 (6.5%) of the children receiving them, and all of these children played at home. Most of these children (n = 8) were rewarded by permission to play another computer game after first playing GraphoGame.

Play sessions were rarely initiated by the child. Only 3.6% of the at-school players and 8.9% of the at-home players were reported to play typically on their own initiative. At school,
the sessions were most commonly teacher initiated (53.6%), whereas at home, the decision was typically made by the child and the parent together (48.1%). Limiting the time used for playing was more common among at-school players than at-home players. At home, 38.8% of the players were allowed to play freely as long as they wanted, whereas at school, this was possible only for 7.0% of the players. In both learning environments, it was most common that the child and adult decided together how long the session should be (72.1% of the at-school players, 47.5% of the at-home players).

We used regression analysis to investigate whether adult involvement was related to children’s playing time, engagement, or learning. To enable the analysis, two categorical variables (the initiation of the play sessions and the decision about the play session duration) were recoded into one new variable that measured the degree to which children’s playing times were controlled by the adults. High control suggests that the adult alone decided both when and how long the child should play \((n = 23)\); moderate control suggests that the adult alone decided one of the two aspects, and the other was decided by the adult and child together or the child alone \((n = 61)\); mild control suggests that both of these aspects were decided by the adult and child together \((n = 46)\); and low control suggests that the child alone decided at least one of these aspects and neither of the aspects was decided by the adult alone \((n = 32)\). According to the \(t\)-tests, the teachers controlled children’s playing times more than the parents did (see Table 1).

The regression analyses were performed separately for at-school and at-home players. The results concerning playing time and engagement are reported in Table 4. None of the involvement variables could significantly predict total playing time either at school or at home. At school, the teacher’s control over playing times had a marginally significant negative association with playing time \((p = .074)\). Regarding engagement, none of the variables predicted it significantly at school. However, at home, both encouragement and control over playing times had a negative association with the child’s engagement. Together, the three involvement variables predicted approximately 21% of variance in the child’s engagement in GraphoGame play at home.

### Table 4. Regression Model with Adult Involvement Variables as Predictors of Total Playing Time and Engagement.

<table>
<thead>
<tr>
<th></th>
<th>School</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Home</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(B)</td>
<td>(SE) (B)</td>
<td>(\beta)</td>
<td>(p)</td>
<td>(B)</td>
<td>(SE) (B)</td>
<td>(\beta)</td>
<td>(p)</td>
</tr>
<tr>
<td><strong>Playing time</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
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<td>.695</td>
<td>.695</td>
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<tr>
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<td>.843</td>
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<td>.536</td>
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<td>.074</td>
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<td>-.10</td>
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<td>.431</td>
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<td>.06</td>
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<tr>
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<tr>
<td>(R^2 = .21)</td>
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</tbody>
</table>
Hierarchical regression analysis was used to explore the association between adult involvement and the child’s reading skill (Table 5). The pretest score was entered at the first step to control its effect and the involvement variables at the second step. At school, teacher involvement was not significantly associated with the posttraining reading test score. At home, the only significant variable was participation during sessions ($p = .042$), which was positively associated with the children’s posttraining test score.

### Table 5. Hierarchical Regression Model with Adult Involvement Variables as Predictors of Reading Skill Development.

<table>
<thead>
<tr>
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<th>Step 1</th>
<th></th>
<th></th>
<th>Step 2</th>
<th></th>
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<td></td>
<td>B</td>
<td>SE</td>
<td>β</td>
<td>$p$</td>
<td>B</td>
<td>SE</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Reading pretest</td>
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<td>0.10</td>
<td>.75</td>
<td>&lt;.001</td>
<td>0.84</td>
<td>0.12</td>
</tr>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>0.18</td>
<td>1.19</td>
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<td>-</td>
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**DISCUSSION**

The results of this study suggest that GraphoGame training was more effectively put into practice at school than at home. Play sessions were more frequent and total playing time longer at school than at home. Parents’ and teachers’ reports revealed that difficulties in following a regular playing schedule were more common among parents than among teachers. Adult evaluations and children’s self-reports suggested that at-home players were less engaged in playing the game than at-school players. Additionally, at-school players’ interest in reading seemed to increase during the training, according to parental ratings, which may be because of their positive experiences with GraphoGame. These findings support earlier studies suggesting that children do not like to spend time with educational software at home (Holmes, 2011; Kerawalla & Crook, 2002, 2005).

Despite the higher playing time and engagement of at-school players, the reading skill of at-home players seemed to develop more during the training. A likely reason for this was the higher beginning level of home players, which helped them to gain more from the reading instruction that they received during the training period. The children who played at school probably had more serious issues in learning to read and therefore would have needed more intensive training to achieve gains similar to the at-home players. Earlier studies have shown
that a GraphoGame-focused intensive training produces significant learning gains (Kyle et al., 2013; Lovio et al., 2012, Saine et al., 2011), although less frequent sessions (two or three times a week) do not (Peltomaa, 2014; Uusitalo-Malmivaara, 2009). Thus, even though at-school players used GraphoGame more than at-home players, training sessions may still have been too infrequent (on average three times a week) to produce larger gains in learning. On the other hand, at-home players may have benefited from the fact that their training was in addition to the reading instruction that they received at school and that the at-home GraphoGame sessions did not interfere with any lessons at school. However, because of the absence of control groups, it is difficult to say to what extent the training helped the children’s reading skills to develop or whether these results reflect only the typical development of children’s reading skills during the first few months of formal instruction, particularly in a transparent language such as Finnish.

There were certain differences between at-home and at-school players at the beginning of the training, but they did not seem to explain the associations between the learning environment and the child’s playing time, engagement, and learning. However, these differences may offer clues to the motivation for use of educational games in different learning environments. In this study, at-home players seemed to be less interested in reading and writing activities than at-school players, whereas at-school players seemed to be poorer readers than at-home players. This may suggest that parents decided to participate in the study because they were worried about their children’s lack of interest in reading and writing; they may have expected GraphoGame to engage their children in learning more effectively than traditional ways of instruction. In contrast, teachers may have been more eager to participate because they were worried about their pupils’ difficulties in reading acquisition. Teachers may have been more committed to following a regular training schedule than parents because they expected this to be important for these children’s learning. At home, parents may have hoped that the game would motivate their children to play without much need for adult intervention. This may imply that parents expect, first and foremost, that digital learning games are engaging and fun and, thus, naturally motivating for those children who are not interested in the subject. This is in accord with Kerawalla and Crook (2005), who found in their interviews that parents and children considered enjoyment as the central criterion for good educational software, with educational benefits tending to receive less attention.

Similar to the observations of Kerawalla and Crook (2005), parents were generally not very actively involved in their children’s learning during the GraphoGame sessions. At-home, children typically played alone and had more freedom in deciding when and how long to play than children who played at school. Parents were nevertheless quite active in encouraging children to play, and some of them used rewards as motivators, which none of the teachers did.

Teacher involvement during training was not associated with children’s engagement or learning. We found only a weak negative association between the teachers’ control over playing times and the total playing time. This may suggest that teachers who needed to set firm limits on playing could not allocate much time for GraphoGame sessions within their schedule. It appears that the teachers’ role in the children’s learning via GraphoGame at school was small, which may be because of the children’s generally high engagement in using the game at school, meaning that adult encouragement and support was less needed in the classroom than at home. However, the data included only 27 teachers, and most teachers were involved with more than one child’s GraphoGame use, which may have affected the results concerning the teachers’ role.
Parental involvement seemed to be more strongly associated with their children’s engagement and learning. Both encouragement and control over playing times were negatively associated with children’s engagement. Perhaps parents were trying to make reluctant children play more by actively encouraging them and telling them when and how long to play. This may be a poor strategy in a learning environment where children are used to having more choice concerning the activities they engage in. Prior research has shown that parental involvement strategies that aim to control children’s behavior tend to undermine intrinsic motivation and achievement (Pomerantz, Moorman, & Litwack, 2007). In contrast, parent’s participation during sessions seemed to be positively associated with the development of the child’s reading skill. The support provided by parents during sessions or their mere presence may have helped these children to gain more from the game. Equally possible, however, is that the parents of these children were generally more supportive of their children’s learning, producing higher achievement in school, which would also show in the GraphoGame reading test scores. Whether young children can truly benefit from parental presence and support during the use of a learning game such as GraphoGame, designed mainly for a child’s independent use, is an interesting topic for future studies.

When considering these results in the light of the self-determination theory (e.g., Ryan & Deci, 2002), it seems possible that GraphoGame sessions at school were better able to satisfy children’s needs for competence, autonomy, and relatedness. First, the at-school players, children who were struggling with reading acquisition, were able to experience success through the adaptive game format, something they may have lacked in their other reading lessons. The level of reading skill was higher for children using GraphoGame at home, and perhaps they felt quite competent as readers already at the beginning of the training so the successful experiences with the game were less crucial for their self-image as learners. In addition, the experiences of success may have a stronger positive impact when they occur at school in the presence of a teacher rather than at home, where there may be no one to see the child’s good performance. Second, as prior research suggests, the at-home players would be accustomed to having autonomy in choosing which activities to engage in at home, whereas the GraphoGame sessions usually were initiated, at least in part, by parents. This may have felt like a limitation of choice and decreased the children’s motivation to play. When at school, children are used to less autonomy, and so an opportunity to play GraphoGame, a game in which the child is in control, may have felt like an increase in freedom and choice. Third, the presence of teachers during GraphoGame sessions, and the fact that in most of the schools in this study, some of the classmates also participated in the GraphoGame activities, may have increased each child’s sense of relatedness during training. At home, the child was most likely the only person in the family who used GraphoGame, which would not support the sense of relatedness.

This study has a few limitations. Because of the correlational nature of the study, it is difficult to say anything about the cause–effect relationships. For example, parental involvement may have affected these children’s engagement and learning, but it is also possible that the child’s behavior prompted some parents to get involved in the training. In addition, the children were not randomly assigned into school and home player groups, which means that there may have been some other factors not controlled in this study that explain the observed differences between the two learning environments. However, as the observations concerning playing time and engagement in this study were in line with the earlier studies addressing home use of educational software, it seems quite safe to conclude that the learning environment plays
GraphoGame at school versus at home

an important role in children’s experiences of digital game-based learning. Moreover, the absence of a control group makes it impossible to determine to what extent the GraphoGame training affected the development of the children’s learning and general reading interest.

Other shortcomings in the motivational design of the GraphoGame version used in the study are noted, such as the absence of multiple, clear goals and the shortage of opportunities for making choices (for a more detailed discussion, see Ronimus et al., 2014), which may have affected the results. Some teachers and parents also reported that the game was too difficult for some of the players. A more carefully designed game with a higher motivational appeal might have reduced the differences observed between the at-home and at-school players in this study.

There were also limitations in the measurements. Because the study was Web-based and the participants were children, the measurement of engagement needed to be simple. However, prior studies indicate that children tend to favor the positive end of the scale when rating their experiences with computer games (Read & MacFarlane, 2006; Sim, MacFarlane, & Read, 2006). Therefore, the method used for measuring the children’s own experiences may have provided an overly positive impression of the children’s levels of engagement and concentration. In addition, single-item measures were used in the evaluations of motivation and concentration, which may have been too simple a method to evaluate a multidimensional construct such as engagement. Finally, the measurement of adult involvement was limited. It did not gather any detailed information regarding how the adult interacted with the child during training, such as whether the support provided related more to the content of the game or to the technical features. In the future studies, the quality of support should be investigated in more detail to enable a better understanding of how parents and teachers can foster children’s engagement and learning via digital game-based learning.

CONCLUSION

The results of this study suggest that the context of use is an important aspect that should not be ignored in the design of digital games for learning. Evidently, especially in the home environment, the motivational design of the game is of crucial importance, whereas the learning effectiveness seems to be the most essential aspect at school. Children seem to be eager to use educational games at school, and therefore, the games that are intended to be used at school could strictly focus on the learning content. In educational games intended for home use, it seems necessary that these games also include features that make learning seem more like play than work. Gaming aspects such as points, rewards, and goals unrelated to learning are familiar to children from their noneducational digital game experiences. Furthermore, the game features should support the child’s sense of competence and autonomy. In regard to parental engagement in the child’s at-home learning activities, features that would encourage parents to become more involved in the use of these educational games could be potentially effective in supporting children’s engagement and learning.

ENDNOTE

1. More information on GraphoGame is available at http://info.graphogame.com
REFERENCES


Authors’ Note

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IMPACT OF STATUS AND MEME CONTENT ON THE SPREAD OF MEMES IN VIRTUAL COMMUNITIES

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Abstract: We examined the influence of meme consistency (vs. inconsistency) and intragroup status on the spread of memes in virtual communities. Prior research suggests that information consistent with the theme of the group is remembered better and that ideas threatening to the group identity are rejected. In addition, previous research shows that low-status group members mimic high-status members and communicate with them to seek information and approval. We analyzed social interactions among members of four online forums from January 1, 2010, to February 21, 2014. Contrary to our prediction, our results show that memes initiated by low-status members spread faster than memes started by high- or moderate-status members. In line with prior research, memes that were consistent with a forum theme were spread more frequently than inconsistent memes.

Keywords: status, influence, meme, norm, social network, computer-mediated communication.
INTRODUCTION

In the investigation of culture, the memetic approach shifts focus from the individual to social interactions (Gabora, 1996), which in online communities involve participation in discussions resulting in information exchange. To describe these informational units, Dawkins coined the term “meme” and defined it as “a unit of cultural transmissions, or a unit of imitation” (Dawkins, 1976, p. 192). Others have defined memes as an instruction for behavior passed on through imitation (Blackmore, 1999), a “unit of cultural evolution and selection” (Wilkins, 1998, p. 56), and an informational pattern that can be copied from one brain to another (Heylighen, 1998).

The popular usage of the meme concept is synonymous with the spread of funny words or phrases or Internet pictures or videos. However, this definition is narrower than the original meaning of the word and therefore scholars have begun to use the term “Internet meme” defined as “a piece of culture, typically a joke, which gains influence through online transmission” (Davison, 2012, p. 122). Shifman (2013) defines Internet memes as “units of popular culture that are circulated, imitated, and transformed by Internet users, creating a shared cultural experience” (p. 367). Most investigations into memetic communication have focused on Internet memes to understand cultural trends and digital culture (Milner 2013a; Shifman, 2013), participation in communities (Milner, 2013b), and spreadability (Jenkins, Ford, & Green, 2013; Miltner, 2014; Shifman, 2012).

Although Internet memes have received more scholarly and public attention, a meme in its broader definition is any piece of information or practice that can be transmitted from one person to another (Gabora, 1996). When individuals encounter information through reading, listening, or observation, the information is transmitted from one person to another, leading to the transfer of information (Heylighen, 1997, 1998). Thus, manipulating and sharing a picture on the Internet and imitating the language of another user in a post are examples of information transmission and transfer. When these units of information are transferred from one individual to another, the meme can influence the behavior of the recipient (e.g., Adams & Dzokoto, 2007; Robles-Diaz-de-Leon, 2003); therefore, examining how memes spread can provide insights into how a culture evolves.

The process through which a meme is transferred from one person to another is key to understanding how the meme influences cultural evolution. Gabora (1996) proposed a theory of how memes evolve and spread. According to her, analyzing how a meme is used provides a way to investigate the concepts and by-products of the social interactions of a group. The theory provides a framework for investigating how memes are created, retained, and transmitted from one individual to another. When the meme is altered, either from transmission errors or recombination with existing ideas, variation occurs. Variation of informational patterns results in meme selection due to competition whereby memes that are not suitable in a particular context will fail to spread. The classic diffusion study by Ryan and Gross (1943) investigating the adoption of hybrid seed corn (i.e., a meme) showed the competition of ideas due to variation and the success of an idea that is more suited for a specific context. The idea of hybrid seed corn was a variation of and in competition with ordinary seed corn. Adoption of the hybrid seed corn was facilitated by informational campaigns and through observing the early adopters. In this framework, replication occurs when the concepts stored in the mind are transformed into an imitable state, such as behaviors or language. Gabora (1996) argued that the introduction of new information into a group
changes the relationship between the group and the meme and leads to the generation of new memes. For example, information about hybrid seed corn changed the farming practices of the community in the study by Ryan and Gross (1943), which led to the new practice of farming hybrid seed corn.

Heylighen (1998) proposed four stages that a meme goes through when it is transferred from one person to another: assimilation, retention, expression, and transmission. Assimilation of a meme involves noticing it, understanding it, and accepting it before it is integrated into memory. After successful assimilation, a meme has to be retained in memory. The uniqueness of the meme, frequency of presentation, authority of the source, how easy it is to express, consistency with norms of a culture, and its usefulness to an individual will influence its retention (Heylighen, 1997, 1998). Lastly, transmission involves expressing a meme retained in memory and it being copied by another individual. At each of these stages, a meme is subject to selection, whereby some memes may fail to be assimilated, retained, expressed, or transmitted. As shown by Bartlett (1932), individuals assimilate and remember information differently, which produces variations of the idea. Variations from either transmission errors or through recombination with other ideas can produce a new meme (although the point where a variation becomes a new meme is difficult to pinpoint). A meme that is successfully expressed and transmitted goes through the cycle again in another individual’s brain.

A meme’s survival depends on how easily it can be transmitted from one brain to another (Blackmore, 1999, 2001). Memes that can be easily expressed will have a higher chance of surviving because spread depends on transforming the memory of the idea into a form that other individuals can imitate, such as speech, writing, or actions (Blackmore, 1999; Heylighen, 1998). In addition, memes that are similar to other known memes have a higher chance of spreading (Gabora, 1996). For example, the spread of the “anchor baby” meme (the idea that adult undocumented immigrants in the United States have children to gain legal status) can be attributed to the usage of a similar meme used in the 1980s and 1990s, namely the “anchor child” (the idea that children legally immigrate to the United States for the purpose of sponsoring family members), both of which have the same racist and anti-immigrant connotations (Ignatow & Williams, 2011). The examples of the hybrid seed corn usage (Ryan & Gross, 1943) and the “anchor baby” meme (Ignatow & Williams, 2011) show that the adoption and spread of memes is influenced by social factors and the context of the culture.

Social Identity Perspective

Although the characteristics of a meme contribute to how it spreads within a culture, the individuals and the dynamics of the group play roles in the spread of the meme as well. Social identity (Tajfel & Turner, 1979) and self-categorization (Turner, Hogg, Oakes, Reicher, & Wetherell, 1987) theories, when combined into a social identity perspective, provide a unified theoretical framework from which to explain the relationship between social interactions and the spread of memes. According to the social identity perspective, individuals seek to gain or maintain a positive and distinct social identity (Tajfel & Turner, 1979). When group members define themselves in terms of the identity of the group, they depersonalize, or self-stereotype, in line with the group’s prototypical norms (Turner et al., 1987). Because of this relationship between the group and the individual, group members are influenced by the norms of the group.
Group norms are attitudes, beliefs, and behaviors that are characteristic and distinctive to the group (Hogg & Reid, 2006). For new members, the norms, values, and prototypical qualities of the group are more readily accepted when individuals feel psychologically connected to the group (Livingstone, Haslam, Postmes, & Jetten, 2011). Greater identification with the group predicts greater adherence to the prototypical norms and values that reflect the group content (Reicher, Spears, & Haslam, 2010). Thus, the social identity approach provides a framework to study memes because the spread of memes is affected by the flow of influence (e.g., high status versus low status) in a group. Memes introduced by high-status members are more likely to be spread because low-status group members are seeking information and approval from higher-status in-group members (Dino, Reysen, & Branscombe, 2009). Further evidence for the conformity shown by low-status members is research showing that low-status members are likely to mimic higher status members (Cheng & Chartrand, 2003). In addition, individuals with high group identification are more likely to embrace and spread the ideas that are normative to the group (Reysen & Lloyd, 2012). Furthermore, previous studies (Bettencourt, Charlton, Dorr, & Hume, 2001; Jetten, Spears, & Postmes, 2004) have shown that group members engage in behaviors that improve or maintain the group’s positive distinctiveness. As a result, group members are more likely to spread memes that highlight the uniqueness of the group.

**Group Norms**

For a group (or culture) to function, some rules must exist to achieve coherence in the group (Feldman, 1984). Group norms can also be described as a set of rules and expectations that apply to all group members and determine acceptable behavior (Postmes, Spears, & Cihangir, 2001). In online groups, the creators of virtual communities usually set out basic rules that every member must comply with in order to be accepted or to remain part of the group. Groups typically do not set or enforce norms for all types of situations (Shaw, 1981); however, some informal rules are enacted through how the individuals interact (Feldman, 1984). For example, introducing a political question in an entertainment discussion, although allowed by the formal rules, usually would be ignored or informally reprimanded.

Group norms are important in the maintenance of a group. Norms ensure the group’s survival, facilitate prediction of how individuals will act in certain situations, promote positive social interaction (e.g., banning discussions of politics in an entertainment forum), and allow the group to project a distinct identity (Feldman, 1984). Individuals with high group identification are more likely to comply with norms that project the group’s positive distinctiveness (Jetten, Spears, & Manstead, 1997). Concepts that are consistent with group norms are more likely to be used in social interactions between and among group members. For example, several studies have shown that information consistent with known stereotypes is remembered better than information that is inconsistent (e.g., A. E. Clark & Kashima, 2007; Kashima, 2000; Kashima, Lyons, & Clark, 2013). On the other hand, inconsistent concepts are less likely to be introduced to the group and are ignored when they are (e.g., some nonpolitical forums do not allow the discussion of politics). Whereas identification and in-group bias are more pronounced when the group is under threat (Tajfel & Turner, 1979), information that poses a threat to the group may be ignored by members as a way to prevent viewing the group as less positive and distinct. When the group is under threat, group
members tend to attempt to strengthen the in-group and show greater adherence to group norms, which are highly influential for directing the behavior of group members (Jetten, Postmes, & McAuliffe, 2002). Thus, concepts are adopted differently depending on the context of the group.

In online forums, group members utilize computer-mediated communication, which can offer anonymity. The social identification model of deindividuation effects (SIDE; Spears, 1995) builds on deindividuation theory (Reicher, 1984) and self-categorization theory (Turner et al., 1987) to describe how anonymity and identifiability affect social interactions in a group. According to the SIDE model, anonymity influences group cohesiveness and the extent to which individuals are attached to the group, which increases the influence of group norms and, consequently, results in individuals defining themselves as part of the group (Postmes, Spears, & Lea, 1998). When group identity is salient, anonymity increases the norms’ social influence (Postmes & Spears, 1998; Postmes, Spears, Sakhel, & Groot, 2001; Spears, Lea, & Lee, 1990). In addition, anonymity fosters closer relationship formation by reducing the risks associated with self-disclosure, allowing individuals to share more (Bargh & McKenna, 2004). When individuals disclose key aspects about themselves, it leads to the formation of closer relationships (Bargh, McKenna, & Fitzsimons, 2002; McKenna, Green, & Gleason, 2002) and they consider the relationship important to their identity (McKenna et al., 2002). Anonymity also allows individuals with culturally objectionable social identities (e.g., fringe political beliefs or homosexuality) to join groups, which impacts the individual’s identification with the group and the influence of the group norms (McKenna & Bargh, 1998). In online forums where users are required to create accounts before they can post to discussions, a user assuming anonymity would be shielded only from being linked to his or her real-world identity. Thus, an individual is assessed by his or her contributions to the forum, which can be tracked for as long as the individual uses the same credentials. Most forums use the total number of posts by an individual to determine status. In addition, individuals gain credibility and a following depending on their interactions with other group members.

Research in online communities has shown that individuals tend to share more information than they would in face-to-face communication, a phenomenon known as the online disinhibition effect (Suler, 2004a, 2004b, 2005). In addition to anonymity, Barak, Boniel-Nissim, and Suler (2008) identified other factors contributing to disinhibition, such as invisibility from the use of text (see also Suler, 2004b), delayed reaction to a post, and the neutralization of status from the real world. Bagozzi and Dholakia (2002) presented a model of virtual community participation in which internalization (i.e., congruence of one’s values with values of another group member) and identification (i.e., how individuals define themselves in terms of the group) were found to significantly predict participation. Building on the virtual community participation model, Dholakia, Bagozzi, and Pearo (2004) proposed a social influence model of consumer participation in virtual communities in which group norms and social identity were the key constructs and found that the norms of the group strongly influenced group intentions to participate in online communities. In anonymous online groups, norms are transmitted from members familiar with the norms to those less familiar, effectively influencing behavior (Postmes, Spears, Sakhel et al., 2001). Thus, memes that are consistent with group norms are more likely to spread.
The Present Study

The purpose of the present study was to examine the influence of meme consistency (vs. inconsistency) and intragroup status on meme spread. We examined the spread of memes used by group members in four online communities. Based on prior research showing that information consistent with the group is remembered better and that ideas that threaten the group’s identity are rejected, we predicted that memes that are consistent with the group theme would spread faster than inconsistent memes. Additionally, based on prior research showing that low-status group members communicate with high-status members to seek approval (Dino et al., 2009; Reysen & Lloyd, 2012) and low-status members mimic high-status members more often (Cheng & Chartrand, 2003), we predicted that memes from high-status (vs. low- or moderate-status) group members would spread faster.

METHOD

We first describe some terms before proceeding. A forum is a collection of posts unified by a common topic. A post is an individual comment or question from a member of a forum. A thread is a series of posts related to a common specific topic within a forum, originating from a single post from a member of that forum. For example, within a forum on political issues, a member could comment on Obamacare (a post), and then others could post comments or questions based on that original post, creating a thread. We collected data posted from the first available public thread to February 21, 2014, but only analyzed the data from January 1, 2010, until February 21, 2014, because data collected before this date did not contain the memes of interest for this study (see the end of this section for more information on how memes were selected). We chose this particular end date for analysis because this was the last day of data collection. Below we distinguish between these two periods of time as the “data collection period” versus the “analysis period,” respectively.

Forum participants (N = 129,947) comprised individuals contributing to discussions in four publically accessible online forums. Two forums focused on topics related to entertainment: a special-interest area related to pop-culture media and a recreational motorcycling group. The other two forums focused on a variety of topics related to political issues (e.g., gun laws, immigration, health care). We used a web crawler to collect information from the forums, which led to differences in the quality of data collected because of communication errors or programming issues. After verification of the data collected, four forums were selected from a pool of forums to be analyzed. These forums contained primarily United States-based discussions, and the forums were categorized based on the content of the majority of topics posted. Forum 1, trekbbs.com, was categorized as entertainment and had 24,427 users and 11,931 threads during the data collection period. Forum 2, advrider.com, was also categorized as entertainment and had 69,058 users and 58,745 threads. Forum 3, straightdope.com, was categorized as political and had 9,940 users and 13,941 threads. Forum 4, defensivecarry.com, was also categorized as political and had 26,522 users and 62,473 threads. We captured all publicly available textual content posted to each forum. For each post, we recorded the user name and the date and time of the post. In addition, all posts were grouped by thread. The user who created the thread was classified as
the thread starter and the rest of the comments within the thread were treated as responses to the thread. The first mention of the meme in a thread was classified as the point of creation and this could occur at any point in the thread. Some forums had discussions from before the analysis period, and thus users who did not participate within this period were not included in our analysis. A total of 3,750,933 individual posts were collected from the four forums within the analysis period and, of those, 91,306 contained one of the memes we included in this study or its variants (e.g., potential misspellings; see the Appendix). See Table 1 for a summary of the forums investigated, including both the data collection and analysis periods. From this point, we only refer to data from the analysis period.

To determine the status or influence of participants, we calculated each individual’s degree of centrality within each forum. To accomplish this, posts were divided into two categories: (a) original posts and (b) reply posts. Original posts were defined as any post that was the first post in a thread and, reply posts were defined as any post that was created in response to an original post. The status of in-degree and out-degree for each participant was then calculated automatically (via the SAS statistical package, Version 9.3) by counting original and reply posts. In-degree is a measure of incoming connections (i.e., replies by other individuals to one’s original post) and out-degree is a measure of outgoing connections (i.e., posts of any kind made by an individual). Out-degree was calculated as the total of all posts (original or reply) created by an individual; in-degree was calculated as the number of replies by others to an original post created by that individual (see Freeman, 1977). In-degree and out-degree were then divided into the categories of high and low: High scores were those above the mean, and low scores were below the mean. Individuals with a high in-degree (i.e., a large number of people responding to a topic thread the participant started) and high out-degree (i.e., a large number of original or reply posts to other participants’ threads) scores were classified as high status. Individuals with a high in-degree and a low out-degree or with a low in-degree and a high out-degree were classified as moderate status. Individuals with a low in-degree and low out-degree were classified as low status.

We selected 100 memes based on Google search trends in the United States from 2010 to 2014 that reflected entertainment (e.g., gangnam style, twerk, Cartman, thrift shop) and political

Table 1. Summary of Forums Studied and Data Collected.

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<td>24,427</td>
<td>11,931</td>
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<td>advrider.com</td>
<td>69,058</td>
<td>58,745</td>
</tr>
<tr>
<td><strong>Political</strong></td>
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<td></td>
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<td>straightdope.com</td>
<td>9,940</td>
<td>13,941</td>
</tr>
<tr>
<td>defensivecarry.com</td>
<td>26,522</td>
<td>62,473</td>
</tr>
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<td><strong>Total</strong></td>
<td>129,947</td>
<td>147,090</td>
</tr>
</tbody>
</table>
Meme spread in virtual communities

topics (e.g., Obamacare, Romneycare, socialist, sequestration). The categorization of memes for this study was based on their classification on the Google search trends lists, and the 100 memes were selected based on the frequency of usage in the four forums for the period analyzed (see the Appendix). Frequency of usage was calculated by counting any posts that contained any mention of these memes or their variants. There were 61,386 posts containing a political meme and 29,920 posts containing an entertainment meme across all forums. Usage of a meme was determined by performing case-insensitive searches for these memes and their variants in each post within the data. Meme usage was then coded as consistent or inconsistent for the forums (e.g., a political meme used in a political forum was consistent). The spread of a meme was defined as the proportion of posts containing the meme since the first mention of the meme within a forum (i.e., the number of posts containing the meme divided by the total number of posts) within each 30-day period. How fast a meme spread was defined as the change in the proportion of posts containing the particular meme across time, which was calculated automatically using SAS, Version 9.3.

RESULTS

To examine the influence of intragroup status and consistency of memes on the spread of a meme, we conducted a repeated-measures ANOVA with intragroup status and meme consistency as independent variables and proportion of posts containing a meme within 30-day intervals as the dependent variable. Results showed group-consistent memes were used more often than group-inconsistent memes over time, Wilks’ $\Lambda = .75, F(49, 328) = 3.85, p < .001, \eta^2 = .01$. Memes introduced by low-status participants were used more often than those from moderate- or high-status individuals over time, Wilks’ $\Lambda = .68, F(98, 656) = 2.06, p < .001, \eta^2 = .01$. Pairwise contrasts revealed that memes initiated by low-status participants were used more than memes from both high-status, $F(1, 380) = 9.63, p = .002$, and moderate-status participants, $F(1, 380) = 7.41, p = .006$. There was no difference in the usage of memes introduced by individuals of moderate versus high status (see Figure 1). Furthermore, there was an interaction between intragroup status and meme consistency over time for thread starters, Wilks’ $\Lambda = .65, F(98, 656) = 2.09, p < .001, \eta^2 = 0.01$ (see Figure 2). These differences seem to be consistent across all four forums, with no significant differences, $F(3, 373) = 1.8, p = ns$, in the proportion of posts containing a meme within 30-day intervals due to the forum (see Figure 3).

DISCUSSION

The purpose of the present study was to investigate the impact of intragroup status and consistency on the spread of a meme. Our prediction that consistent memes would spread faster was supported. Memes that were consistent with the topic focus of the group were used more than inconsistent memes. However, our prediction that memes started by high-status group members would spread faster was not supported. Contrary to our hypothesis, memes introduced by low-status individuals spread faster than memes started by high-status individuals. Thus, the results showed that memes that were consistent (vs. inconsistent) with the group norms and memes initiated by low (vs. high or moderate) status group members spread faster.
Figure 1. Proportion of posts containing a meme, for each group: consistent and inconsistent meme, and high vs. moderate vs. low intragroup status (see pp. 153-154 for an explanation of intragroup status). Values on the y-axis equal total number of posts containing a meme divided by total number of posts. Consistent memes agree with the content of the forum; inconsistent memes disagree with forum content.

Figure 2. Interaction between meme consistency and intragroup status of the person who started the meme.
Studies investigating the transmission of stereotypes (e.g., A. E. Clark & Kashima, 2007; Kashima, 2000; Kashima et al., 2013; Kurz & Lyons, 2009; Lyons & Kashima, 2001, 2006) have shown that information that is consistent with known stereotypes is remembered better and therefore more likely to be passed on to others. In the context of online forums, discussion of topics that are not relevant to the forum typically is discouraged and, in some cases, violators are reprimanded. Furthermore, consistent with the SIDE model (Postmes et al., 1998), in-group members in relatively anonymous online communities adhere to in-group norms. The results of the present study support the notion that group-consistent information is likely to spread to other group members because the memes are consistent with the in-group norms. In addition, memes can provide background information about a topic. Background information (e.g., assumptions or facts) helps in the understanding of the discussion. In forums, memes can help provide background information (e.g., the use of the often negatively applied term “Obamacare” rather than “Patient Protection and Affordable Care Act” or “Affordable Care Act” can signal
opposition to the law) allowing others quick access to members’ shared assumptions and knowledge. Providing background information helps individuals predict the response of others and to promote positive social interaction by avoiding misunderstanding, which can lead to hostility between group members. Memes that communicate background information about a topic provide utility, a predictor of the spread of memes (Heylighen, 1998), which is a possible explanation why memes consistent with the group spread faster than inconsistent memes.

The results of our study failed to support our prediction that high intragroup status would influence memes to spread faster. Memes started by low-status group members spread faster than memes started by moderate- or high-status members. A possible explanation of this finding comes from an analysis of the spread of the “anchor baby” meme investigated by Ignatow and Williams (2011). Their analysis showed that it was in use in 2003 in a few online sites targeting social and political conservative audiences and only gained prominent usage between 2007 and 2010. In his book *The Tipping Point*, Malcolm Gladwell (2000) attributed the spread of ideas to the principle of “the power of context,” the idea that the spread of memes is influenced by the social context, whereby an idea can spread quickly in one context but not in another. For the “anchor baby” meme, the political context was suitable in that Senator Barack Obama, who has an African father and an American mother, was running for the presidency of the United States in 2007. In United States politics, race plays a big role in elections (Piston, 2010), and thus having an African-American candidate for the presidency made the context suitable for the spread of the meme. Another example is the history of hip-hop, from its roots as a black subculture in the 1970s to its widespread adoption by other communities in the United States as race relations changed (Kitwana, 2006). In other words, in certain contexts low-status group members may be more influential in starting popular memes than high-status members.

However, the lack of support for the prediction that high intragroup status results in a meme spreading faster may point to the credence of the status float phenomenon (Field, 1970), in which new ideas flow from low-status individuals to high-status individuals. According to Field, low-status individuals are more willing to try out new ideas that may not be mainstream. The ideas are then imitated between the low-status individuals until eventually they are incorporated into the mainstream. In line with the adoption of new ideas (e.g., fashion) as a means to achieve distinctiveness, the use of memes in forums may indicate the desire to stand out and achieve status. In online communities, high participation is a marker of leadership and social influence (Huffaker, 2010). Thus, low-status individuals may contribute more unique information to discussions in order to gain status, as compared to high-status individuals who already wield influence. Indeed, previous studies (e.g., Reysen, Lloyd, Katzarska-Miller, Lemker, & Foss, 2010) showed that communication from low-status members contained social presence cues signaling conformity to group norms and ingratiation to the group. Thus, low-status members are more likeable in the discussions because social presence cues have been shown to facilitate trust (Hassanein & Head, 2005). Memes from trustworthy sources are more likely to be spread (Heylighen, 1998), which may explain the finding that memes started by low-status members spread faster.

The findings of this study hold implications for those embarking on information dissemination campaigns. In order to ensure that information is spread quickly within a group, the information should be tailored in a way that is consistent with the group norms. Before disseminating the information, the norms of the group will need to be identified. Because of the differences in groups, information may need to be customized for each targeted group to gain
maximum exposure. Based on Gabora’s (1996) theory on the spread of memes and Heylighen’s (1998) model of how memes are transmitted from one individual to another, information to be disseminated also should be easy to remember and express. In addition, the information should capitalize on common knowledge and assumptions of the (group) culture to establish grounding, which is essential for successful communication (H. H. Clark & Brennan, 1991).

The finding that memes started by low-status individuals spread faster has implications on strategies for influencing the behaviors of a group. Although this finding requires further study, it suggests that targeting low-status members (instead of high-status members) as a starting point for disseminating new ideas may lead to quicker adoption. The idea that low-status members can influence high-status members to incorporate new ideas and effectively change the group norms is consistent with minority influence (Moscovici, 1976, 1980, 1985; Moscovici & Faucheux, 1972). In Grant and Patil’s (2012) minority influence framework, adoption of a new norm can be achieved through the modeling of a new norm by minority group members. Thus, low-status group members can be agents of change for social change and consequently behavior of group members.

There are limitations to consider when interpreting the results of this study. As noted earlier, there are other factors that influence the spread of a meme. For example, memes that elicit emotions (e.g., disgust; Heath, Bell, & Sternberg, 2001) are more likely to be remembered. Thus, other characteristics of the meme itself, beyond consistency to the focus of the group, may be better predictors of the spread of memes. Future research may include additional factors to examine the spread of memes. In addition, the categorization of memes is likely to bias the political category. Some entertainment memes could be classified as political memes in some contexts, and vice versa. Another limitation of this study is that our definition of a meme was narrower than suggested by theorists. We only included memes that were spelled in a particular way and their common misspellings. This definition fails to account for other forms of the meme that may be informationally equivalent. Future research may need to employ more sophisticated linguistics analysis tools to discern words and phrases communicating the same idea. In addition, future studies may need to include more categories for a more accurate categorization of the meme. For example, the political categories could be split into several categories such as right-wing or left-wing or the entertainment category split into music, movies, or television show. A more nuanced classification of memes should help determine the context in which the meme was used and allow better analysis of meme spread. Lastly, the present research is quasi-experimental. Future researchers may manipulate the posting of memes in online groups and observe the subsequent spread or lack of inclusion within various online groups.

To conclude, online Internet forums are an apt environment for researchers to examine intragroup processes. In the present study, memes that were consistent with the group and initiated by low-status members spread faster than memes that were inconsistent or started by high- or moderate-status members. Given the surprising result regarding status and adoption of memes, greater research examining the possible power of lower-status members is needed.

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Kurz, T., & Lyons, A. (2009). Intergroup influences on the stereotype consistency bias in communication: Does it matter who we are communicating about and to whom we are communicating? *Social Cognition, 27*(6), 893–904.


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Appendix

List of memes used

The memes (and variation in parentheses) included topics related to entertainment (presented first) and politics.

The memes were selected based on Google search trends in the United States from 2010 to 2014.

<table>
<thead>
<tr>
<th>Meme (variation)</th>
<th>Category</th>
<th>Meme (variation)</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>99 problems</td>
<td>entertainment</td>
<td>anchor baby</td>
<td>politics</td>
</tr>
<tr>
<td>adele</td>
<td>entertainment</td>
<td>barack obama (obama)</td>
<td>politics</td>
</tr>
<tr>
<td>adrian peterson</td>
<td>entertainment</td>
<td>big bird</td>
<td>politics</td>
</tr>
<tr>
<td>american idol</td>
<td>entertainment</td>
<td>big government</td>
<td>politics</td>
</tr>
<tr>
<td>born this way</td>
<td>entertainment</td>
<td>birther</td>
<td>politics</td>
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<tr>
<td>cartman</td>
<td>entertainment</td>
<td>boston marathon explosion (boston marathon)</td>
<td>politics</td>
</tr>
<tr>
<td>duck dynasty</td>
<td>entertainment</td>
<td>bunch of malarkey (malarkey)</td>
<td>politics</td>
</tr>
<tr>
<td>gangnam style (gangnam)</td>
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<td>cash for clunkers</td>
<td>politics</td>
</tr>
<tr>
<td>google+ (google plus)</td>
<td>entertainment</td>
<td>christian nation</td>
<td>politics</td>
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<td>holy grail</td>
<td>entertainment</td>
<td>edward snowden (snowden)</td>
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<td>entertainment</td>
<td>establishment</td>
<td>politics</td>
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<tr>
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<td>entertainment</td>
<td>evangicals (evangelical)</td>
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<td>entertainment</td>
<td>george zimmerman</td>
<td>politics</td>
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<td>justin bieber (bieber)</td>
<td>entertainment</td>
<td>government shutdown</td>
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<td>entertainment</td>
<td>gun control laws</td>
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<td>entertainment</td>
<td>hurricane katrina (katrina)</td>
<td>politics</td>
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<td>lean in</td>
<td>entertainment</td>
<td>hurricane sandy</td>
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<td>politics</td>
<td>you didn’t build that (you did not build that)</td>
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</table>

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**BOOK REVIEW**


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Significant technological advances over the last 250 years continue to revolutionize how we humans perceive, understand, and interact with the world around us. Fundamentally, they have opened up fresh perspectives on how we interact with each other in both the physical and virtual worlds. Communication technologies now allow us to find, contact, and carry on meaningful discussions with people a half a world away with scant consideration of time or geography; transportation technologies bring us into first-person contact with others both in new locales and in our everyday hometowns. As never before in human history, technology is multiplying the venues and opportunities for people from different national, regional, ethnic, familial, professional, and religious cultures to meet and mingle.

Yet, many of these interactions are less than successful—and some outcomes tragically poor or even disastrous. Academics and practitioners have invested much time and activity in researching, theorizing about, and attempting to instruct individuals and organizations about the various aspects of perception, expectations, and behavioral patterns that make groups of humans, who share so many biological and behavioral similarities, distinct from each other. The challenges these professionals face include understanding (a) how one’s own multiple and overlapping cultures and identities affect what one values and how one perceives, interacts, and behaves; (b) how individuals deal with missed cues and misunderstanding when interacting with someone who has dissimilar ways of perceiving, interacting, and behaving; and (c) how to bring the knowledge of both parties’ realities into play simultaneously to build “bridges” and create reflective processes that can improve the interaction, enhance collaboration, and nurture relationships.

Even with the extensive research and exponentially growing literature focused on these seemingly infinite facets that may appear in intercultural interactions, a debate has been raging among theorists about how culture affects the individual on the intrapersonal level. Is culture...
“software of the mind” (Hofstede, 2001), hardwired as predispositions and learning devices into a person’s developing operating system (e.g., Keller, 2008), or a simple toolbox of cognitive perspectives that one can draw on at will in interaction (see, e.g., Friedman, 2014; Weber & Dacin, 2011)? Can or should one try to eliminate the influences of one’s native cultures when attempting to interact with someone dissimilar, or must those influences always and inevitably be in play? In other words, how much agency does the individual have over the group-level aspects of culture that become embedded in each of us both neurologically and environmentally at the moment we are born into a group or decide to become part of one?

Scores of models and theories have been proposed, explored, developed, and offered as tools by researchers in recent decades to explain the role of culture in human relations. Unfortunately, many of these models and theories are turning out to be rather simplistic or essentialist in nature, lacking the crucial sensitivity to circumstances and frames of reference. Although such approaches appear to make the complexity of human interaction—particularly between and among individuals with significantly different perspectives on how to live and behave—easier to grasp, the contexts and potentially important unique components of interaction are too easily diminished or disregarded. Many of these approaches have been highly commercialized and provide the stock-in-trade of what has become a diversity consulting and training industry. Some practitioners in this field may feel threatened by recent explorations and discoveries, particularly in the field of neuroscience, that shed light onto the deficiencies of a number of these theories and practices. The natural outgrowth of such realizations is beginning to be seen in new perspectives that suggest alternative forms of intervention.

Ongoing advances in human biological research are demonstrating how the developing brain, in fact the entire neurological system, functions in such a way as to rely on its earliest imprints of a person’s cultural norms in continuously functioning to organize and interpret incoming stimuli and reinforce these original messages (e.g., Kitayama & Park, 2010), thus influencing and, at times, directly affecting how interaction with others and the world will be carried out (Domínguez Duque, Turner, Lewis, & Egan, 2010). In the coming decades, further technological advances will continue to add significantly to how we understand the holistic nature of the human system and thus how we view the complexity at the nexus of individual agency, group-level influences, and cognitive, affective, and somatic responses. These rapidly developing areas of research confirm that an individual’s endowment and development are intimately related to and influenced by many of the cultural norms and practices of groups into which that individual was born and nurtured (e.g., Fiske & Taylor, 2013; Kim & Sasaki, 2014). As a result, over time, many of the current models and theories on the role culture plays within the individual organism and on the dynamics of his or her group’s norms and behaviors surely will be eliminated or at least profoundly refined—and new theories and applications will emerge.

Amid this rethinking of generally accepted theory and practices comes The Intercultural Mind: Connecting Culture, Cognition and Global Living. Throughout its 240 pages, Joseph Shaules provides a very readable presentation on how what we currently label cognition and culture interact. Seamlessly, Shaules compares and intertwines recent neuroscientific research with traditional perspectives and theories. He uses first-person experience to illustrate how culture is at work within each of us at both the deep unconscious, intuitive level and the conscious, interactive level. Moreover, he shows how the development of a conscious,
reflective, and attentive mind can be the principal and universally available means for recognizing and (re)organizing what unconscious culture produces. On the basis of this process, he underscores the potential for developing better strategies for successful functioning and engagement on a day-to-day, moment-to-moment basis.

Of particular value are the insights found in chapters on “The Architecture of Bias” and “The Language–Culture Connection.” The material found in these chapters enables the reader to understand the presence of unconscious bias as a normal function of the human mind, yet one in which problematic components in everyday speech and behavior can be better managed through strategic yet simple observation of and reflection on one’s own ongoing experiences.

Shaules adopts a metaphor to connect theory with experience by directing us to pay attention to what he labels the “Oz Moment.” He draws on the widely disseminated children’s book, The Wonderful Wizard of Oz, which was written more than a century ago and popularized in musical theater and film. It is the fantasy story of an adolescent girl who is whisked away from her familiar life and environment by a tornado and dropped into a strange land with fantastic characters, behaviors, and settings that she somehow needs to navigate in her effort to return home. Using this metaphor, Shaules highlights the feelings and confusion that one might experience when engaging in an unfamiliar environment or interaction and facing realities that one does not comprehend or perhaps will not know even how to describe. The ability to recognize such Oz moments can alert us to awaken the intercultural mind and to look for fresh perspectives in immediate events by drawing on a wider range of internal resources, thus making it possible to stake out a potentially better direction in one’s forward course.

The Intercultural Mind demonstrates how technology can advance and refine research in the human sciences and open new insights into the many perspectives on interpersonal interaction, whether within one’s familiar culture or in an environment that—or with a person who—is unfamiliar. For both the academic and the practitioner, Shaules’ book offers an integrated and well-conceived presentation on the need for contemporary researchers to consider developing technologies as partners in their exploring theoretical concepts, conducting empirical investigations, and reflectively applying their discoveries to understanding and to work with everyday concepts and practices in an increasingly globalized world. This points to greater promise for the ongoing development of insights and tools that will enable dissimilar people to better understand themselves and each other as cultural beings in their interactions. Developments in both research and applied areas can be a step forward for humanity in its challenge to create collaboration and cohabitation in a multicultural world and for us, as individuals, as we continue on our path toward becoming globally aware and interpersonally enlightened citizens.

REFERENCES


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Human Technology: An Interdisciplinary Journal on Humans in ICT Environments is an interdisciplinary, online scholarly journal investigating the multiple facets of humans in interaction with technologies. Because we are an interdisciplinary journal, we have sought out experts from around the world in a variety of fields related to the field of human–technology. Over the last 2 years, more than 100 scholars, in universities, research organizations, and technology-based businesses, have kindly accepted the invitation to review the dozens of manuscripts submitted and invited for consideration in Human Technology. We are deeply grateful for the time, effort, and wise recommendations these individuals have provided to the editorial staff of Human Technology in assessing suitability for publication and helping improve the manuscripts under consideration.

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