



Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

Internet source evaluation: The role of implicit associations and psychophysiological self-regulation

Lucia Mason^{a,*}, Sara Scrimin^a, Maria Caterina Tornatora^a, Caterina Suitner^a, Angelica Moè^b^a Department of Developmental Psychology and Socialization, University of Padova, Via Venezia 8, 35131 Padova, Italy^b Department of General Psychology, University of Padova, Via Venezia 8, 35131 Padova, Italy

ARTICLE INFO

Keywords:

Source evaluation
Internet reading
Implicit associations
Psychophysiological measures
Self-regulation

ABSTRACT

This study focused on middle school students' source evaluation skills as a key component of digital literacy. Specifically, it examined the role of two unexplored individual factors that may affect the evaluation of sources providing information about the controversial topic of the health risks associated with the use of mobile phones. The factors were the implicit association of mobile phone with health or no health, and psychophysiological self-regulation as reflected in basal Heart Rate Variability (HRV). Seventy-two seventh graders read six webpages that provided contrasting information on the unsettled topic of the potential health risks related to the use of mobile phones. Then they were asked to rank-order the six websites along the dimension of reliability (source evaluation). Findings revealed that students were able to discriminate between the most and least reliable websites, justifying their ranking in light of different criteria. However, overall, they were little accurate in rank-ordering all six Internet sources. Both implicit associations and HRV correlated with source evaluation. The interaction between the two individual variables was a significant predictor of participants' performance in rank-ordering the websites for reliability. A slope analysis revealed that when students had an average psychophysiological self-regulation, the stronger their association of the mobile phone with health, the better their performance on source evaluation. Theoretical and educational significances of the study are discussed.

1. Introduction

Online searching on the Internet to know more on an unfamiliar topic is a routine way to identify and access information. From lower secondary school onward, students use the Internet for school assignments instead of books and libraries, for example, when they need to prepare essays or presentations about topics of the subjects taught, such as history and science. Very often, students are confronted with multiple sources of online information that provide different, if not conflicting perspectives, especially about controversial socio-scientific topics (e.g., global warming, nuclear power). Internet is unparalleled for its opportunities to access a huge number of sources on any topic. Undoubtedly, this is an important aspect of the democratization of our current cultural context. At the same time, however, the infinite body of information made available on the potentially global learning environment by a simple click of the mouse, requires new skills to the students, who must be able to locate, select, and evaluate the sources of information and the information itself (Brand-Gruwel, Wopereis, & Vermetten, 2005; Coiro, Knobel, Lankshear, & Leu, 2008; Tu, Shih, & Tsai, 2008).

* Corresponding author.

E-mail address: lucia.mason@unipd.it (L. Mason).<https://doi.org/10.1016/j.compedu.2017.12.009>

Received 28 March 2017; Received in revised form 22 December 2017; Accepted 23 December 2017

Available online 27 December 2017

0360-1315/ © 2017 Elsevier Ltd. All rights reserved.

As Internet is increasingly being used for educational purposes, the reading of multiple sources is essential in the school context to solve information-based problems (van Strien, Kammerer, Brand-Gruwel, & Boshuizen, 2016).

The purpose of the present study is twofold. On the one side, we aimed at enlarging our knowledge about source evaluation on the Internet by involving younger students than those involved in most investigations. In particular, we focused on pre-adolescents in middle school, which are already consumers of digital information and are required to learn digital literacy. On the other side, we sought to widen the focus on the role of individual characteristics in the evaluation of online sources providing conflicting information on the controversial topics of the health risks associated with the use of mobile phones. We focused on two person-related variables that have been very scarcely explored in educational research in general and not yet in relation to source evaluation, that is, implicit associations of the target object – the mobile phone – with health or no health, and psychophysiological self-regulation. The overall aim is to connect issues from separate lines of research for a more complete picture of individual factors that favor or impair source evaluation skills in pre-adolescents. Deeper knowledge of these factors is important and useful in designing effective interventions that can promote source evaluation skills in middle school students.

1.1. Source evaluation

When looking for information on the Net to know more on an unfamiliar issue, students have likely to deal with multiple sources. First, they must detect relevant information and once accessed, information must be evaluated. Evaluation processes include judgments of essential aspects, such as the relevance and usefulness of the materials accessed (e.g., Hwang, Tsai, Tsai, & Tseng, 2008; Rouet, Ros, Goumi, Macedo-Rouet, & Dinet, 2011; Tu et al., 2008), as well as about the reliability (or credibility) of digital sources (e.g., Bråten, Braasch, Strømsø, & Ferguson, 2015; Bråten, Salmerón, & Strømsø, 2016; Mason, Ariasi, & Boldrin, 2011). In this regard, the term “sourcing” includes noting the source of a document, using source information to interpret a document content or judging its authoritativeness, or using source information in referring to a document's content (Strømsø, Bråten, Britt, & Ferguson, 2013).

Evaluation processes are included in the current theoretical frameworks about information search, use, and comprehension. Specifically, the model of information problem solving (Brand-Gruwel et al., 2005; Walraven, Brand-Gruwel, & Boshuizen, 2009) encompasses various activities, such as defining the information problem; searching, scanning, and processing information; and organizing and presenting the content. Particularly relevant for the purposes of the present work is the processing of information, in which not only its relevance and usefulness is evaluated, but also its quality in terms of truth and veracity, in order to be able to follow up reliable sources. The theoretical model of Multiple-Document Task-based Relevance Assessment and Content Extraction (MD-TRACE, Rouet & Britt, 2011) also includes the evaluation processes behind an effective use of multiple sources. In the third of the five steps included in the model, readers select documents in light of their relevance to the established goal, and then they read and evaluate the accessed information.

However, research has indicated that even at the university level, students show limited evaluation of sources (Brand-Gruwel & Stadler, 2011). For instance, they may recall document information to a limited extent (Braasch, Rouet, Vibert, & Britt, 2012; Strømsø, Bråten, & Britt, 2010), use naïve criteria to justify their evaluation (Mason, Boldrin, & Ariasi, 2010b), or even not notice conflicting information in a set of texts (Kobayashi, 2014). It is therefore not surprising that secondary school students may be uncritical readers (Kiili, Laurinen, & Marttunen, 2008). In this regard, it emerged that only half the middle school participants involved in the study maintained that authoritative sites are more reliable than non-authoritative (Mason, Ariasi, & Boldrin, 2010a). In another investigation, middle school students showed little metacognitive knowledge about source evaluation and did not mention criteria related to the trustworthiness of the websites when evaluating them (Barzilai & Zohar, 2012).

Source evaluation is also essential because it contributes to comprehension of information in multiple documents (Kammerer, Meier, & Stahl, 2016). Several studies have documented that evaluation of online sources and their contents is related to comprehension of the information provided on the Web (Goldman, Braasch, Wiley, Graesser, & Brodowska, 2012; Mason et al., 2011, 2010b; Strømsø et al., 2013; Wiley et al., 2009).

In this regard, source evaluation processes have been termed “validation” and considered as regular components of the comprehension of multiple texts with conflicting information (Richter, 2015). A recent theoretical approach has proposed a two-step model of validation process to account for the empirical evidence available (Richter & Maier, 2016). The first step reflects a routine validation that may detect text-beliefs inconsistencies. This detection influences memory and comprehension of information even when readers are not motivated to defend their beliefs. The second step occurs when readers engage in the elaboration of information inconsistent with beliefs. Based on their reading goals and motivation, readers may come to the construction of a balanced representation of the controversial topic at hand (Richter & Maier, 2016).

A relevant question is therefore: Which individual factors may facilitate or hinder Internet source evaluation? Research has identified a number of these factors. It has been documented that more availing epistemic beliefs about the justification of knowledge, that is, knowledge should be justified by multiple sources, contribute to source evaluation (Bråten, Ferguson, Strømsø, & Anmarkrud, 2014). Epistemic beliefs about knowledge as merely an opinion were negatively related to source evaluation and positively related to reliance on the reader her/himself as source of knowledge (Barzilai, Tzadok, & Eshet-Alkalai, 2015). Similarly, Internet-specific epistemic beliefs are predictors of source evaluation. To exemplify, beliefs in the Web as a reliable source of veracious information was associated with less reflection on the credibility of the read sites (Kammerer, Bråten, Gerjets, & Strømsø, 2013).

Research has also indicated that preexisting topic beliefs are used to assess whether unsupported conclusions have been made against the available evidence (Braasch, Bråten, Britt, Steffens, & Strømsø, 2014) and information content inconsistent with reader's prior beliefs is evaluated as less reliable (Bråten et al., 2016). Moreover, the biased effects of prior attitude strength on both

processing and evaluation of sources and information has been documented in an eye-tracking study by van Strien et al. (2016). Participants with a strong attitude toward the current topic (i.e., organic foods) paid less attention to the logos of the websites with information inconsistent with their attitude. They judged these websites to be less credible, and in an essay reported more information consistent with their attitude compared with participants with a weak attitude. The latter fixated the texts from attitude-inconsistent longer than attitude-consistent websites, whereas there was no difference between the two types of source in the fixation time spent by participants with a strong attitude toward the topic.

Furthermore, topic familiarity is related to source evaluation: When a topic is more familiar, the reader relies less on author expertise than when the topic is less known (McCrudden, Stenseth, Bråten, & Stromso, 2016).

There could be, however, other individual factors affecting the ability to evaluate multiple sources. Here we will consider implicit associations related to the mobile phone and psychophysiological self-regulation.

1.2. Implicit associations

In judging the reliability of a website individuals may rely on their opinions rather than on the authoritativeness of the source. While previous research focused on overt topic beliefs (Braasch et al., 2014), we considered implicit associations. Greenwald and Banaji (1995, p. 8) defined implicit associations as “introspectively unidentified (or inaccurately identified) traces of past experience that mediate favorable or unfavorable feeling, thought, or action toward social objects”. The advantage of measuring implicit attitudes regarding an object or issue is that they are less influenced by social desirability biases, but still influence explicit behaviors (e.g., Cunningham & Zelazo, 2007). The strengths of the evaluative associations between a target object (e.g., the mobile phone) and an attribute dimension (e.g., healthy or unhealthy) is at the basis of the Implicit Association Test (IAT, Greenwald, McGhee, & Schwartz, 1998), a well-known procedure used to measure these associations. Essentially, IAT is a speedy-based categorization task, whose underlying assumption is that individuals react faster to attributes that match a given object (concept) than to attributes that do not match it. The speed of this automatic reaction is considered to reflect the associative strength between the object and the attribute (Greenwald et al., 1998). Despite divergences about the interpretation of the IAT effects (e.g., De Houwer, 2006), social cognition scholars share the issue that it measures an implicit bias which emerges even when explicit self-reports do not reveal any evidence of it (Greenwald, Banaji, & Nosek, 2015).

The influences of implicit associations, which have an emotional basis and are less subject to cognitive control, have been reported in different domains of adolescents' experience. For example, research has indicated the important role played by implicit alcohol-relaxation associations in drinking behavior in combination with specific personality traits (Salemink, van Lier, Meeus, Raaijmakers, & Wiers, 2015), or the role of implicit approach-avoidance associations for highly desired food in reported food carving in the context of problem eating behavior (Kemps, Tiggeemann, Martin, & Elliott, 2013).

In this study, middle school students read websites about the mobile phone and the potential health risks associated with its continuous use, and were asked to rate their reliability, which could be affected by their implicit evaluative association of the mobile phone with health or no health. Young adolescents are already (and increasingly) daily users of the mobile phone to stay in connection with real and virtual friends. According to a recent survey (Lenhart, 2015), 82% of 13–14 years Americans have access to a mobile phone (68% of which to a smart phone). Their parents may tell them that it is not good to stay hours on the phone for various reasons and recommend them a limited use of the mobile device. It is therefore relevant and interesting to examine whether their implicit associations with the mobile phone are related to their evaluation of digital sources about the health consequences of using this electronic device.

Of note is that implicit associations are less influenced by social desirability bias and affect overt behavior. Specifically, implicit associations of the mobile phone with the category “healthy” may lead to consider as unreliable, or less reliable, websites that provide information about serious health risks compared to the pages that present the mobile device as harmless, and vice versa, regardless the real authoritativeness of the Internet resources. In this respect, in the psychological literature there is ample evidence of the so called “myside bias” or “confirmation bias”, that is, the tendency to search, interpret, and provide arguments or evidence in favor of one's position and to disregard arguments and evidence that undermines it (Perkins, Farady, & Bushey, 1991). This bias as documented in the adult literature has also been demonstrated in young adolescents (Kuhn & Udell, 2007; Stanovich, West, & Toplak, 2012).

To our knowledge, no data are available on the role played by implicit associations on source evaluation. Yet, to identify a relationship, either positive or negative, between implicit associations and Web source evaluation is of theoretical and practical importance when considering the issue of the acquisition of digital competencies. In this regard, implicit associations are affected by interventions, thus they can be modified as experimental investigations have demonstrated (Clerkin & Teachman, 2010).

1.3. Psychophysiological self-regulation

Another individual characteristic that may contribute to source evaluation is students' self-regulation in terms of their ability to control one's emotions, thoughts, and behavior, selecting optimal responses to meet situational demands (Gross, 1998; Thayer & Lane, 2000). This ability is crucial for adaptive functioning across various domains of human life (e.g., Davis & Levine, 2013; Klapp, 2016).

Given the important role played by this ability for students' adaptation to the environment and for general functioning, researchers have worked to identify biological somatic marker associated with self-regulation (Kreibig & Gendolla, 2014). Specifically, this marker is the heart rate variability (HRV), that is, the physiological variation in the intervals between heart-beats at rest (Li et al.,

2009), which reflects the influence of vagal nerve on the heart (Porges, 2007). A recent but well-known functional framework has integrated affective regulation, attentional regulation, and heart rate variability (Thayer & Lane, 2000). This model is based on investigations by a number of researchers (e.g., Porges, 1991, 1992; Richards & Casey, 1992; Thayer, Friedman, Borkovec, Johnsen, & Molina, 2000), who suggested that autonomic nervous system regulation, as manifested in cardiac variability, is related to both attentional regulation and emotion. Heart rate variability at rest, in particular, has been shown to be related to attentional control and emotional regulation (Nyklicek, Thayer, & van Doornen, 1997; Porges, 1991, 1992; Thayer et al., 2000). Specifically, HRV at rest indexes the efficiency of central–peripheral neural feedback mechanisms, for example the amount of regulatory resources available to an individual during challenges. Thus, this measure serves to quantify the ability to self-regulate through the organization of physiological resources and appropriate response selection, in the service of goal-directed behavior. Higher HRV reflects better cardiac flexibility and ability of the individual system to respond, and is associated to better outcomes in terms of emotional and cognitive regulation. For example, greater HRV is related to greater executive attention and working memory performance (Hansen, Johnsen, & Thayer, 2003; Sollers, Naumann, Sienbenbrock, Hill, & Thayer, 2010).

HRV can be considered an index of self-regulatory abilities and as such is related with cognitive performance, yet there is only one published study that assessed the role of HRV in predicting reading achievement in school-age children (Becker et al., 2012). Findings however failed to show an effect of HRV at rest. The lack of a positive association between basal HRV and reading comprehension is surprising given the ample literature linking HRV at rest, prefrontal neural activity, and cognitive performance (Thayer, Hansen, Saus-Rose, & Johnsen, 2009). Moreover, it has been found that basal cardiac variability predicted pre-schoolers' listening comprehension together with inhibitory control and verbal ability (Scrimin, Patron, Florit, Palomba, & Mason, 2017).

To date, no data are available on the role played by psychophysiological self-regulation (basal HRV) in relation to an information search task on the Web, which nowadays is a very common activity carried out by students for school assignments and requires a number of cognitive competences. Yet, this is an important individual factor to consider when students read information of unfamiliar topics. It is theoretically legitimate that psychophysiological self-regulation or basal HRV may play a key role in a process of critical reading that is necessary to evaluate the reliability of a website and the veracity of its content. Specifically, higher HRV may enable the readers to establish the reliability of a webpage more accurately even if the informational content is emotionally charged since they are more capable to self-regulate their affective response and hence to better process the information.

For example, a student who has a strong implicit association mobile phone-no health may tend to consider as reliable only websites that provide information about the serious health risks related to the use of the electronic device, regardless of their authoritativeness, as compared to a student who has a less negative, or a positive implicit association. The basal psychophysiological marker of self-regulation may interact with implicit associations of mobile phone-health/no health in the evaluation of information sources about this object.

1.4. The study

This study is the first attempt to examine the role of students' implicit associations related to mobile phones and psychophysiological self-regulation when evaluating online information about an unsettled topic. The study represents an extension to prior educational research for two main reasons: (1) first, we focused on an objective measure, a psychophysiological correlate of self-regulation (i.e., basal HRV), which has been very scarcely investigated in educational research on reading comprehension (Becker et al., 2012; Scrimin, Patron, Ruli, et al., 2017) and not yet in relation to source evaluation on the Internet; (2) second, the role of this psychophysiological marker is examined in relation to implicit associations, which have an emotional basis and are less subject to cognitive control. Specifically, we measured the strength of evaluative associations of the target object, here the mobile phone, with health-no health. Further, of note is that young adolescents', like the seventh graders involved in the study, undergo major physiological and psychological changes, thus their emotionality is particularly relevant when performing a cognitively complex task and, even more, their basal ability to control emotions and thoughts when reading about a very salient object of their life.

The following research questions (RQ) guided this explorative study:

- (1) How do middle school students rank-order for reliability a set of websites about the controversial topic of the potential health risks related the use of the mobile phone and what evaluation criteria do they appeal to?
- (2) Do students' implicit associations mobile phone-health/no health and basal psychophysiological self-regulation correlate with source evaluation as reflected in their rank-order?
- (3) Is there an interaction between basal psychophysiological self-regulation and the implicit association mobile phone-health/no health in predicting source evaluation when controlling for the potentially interfering variables of reading comprehension and working memory?

Based on the previous literature on young adolescent students (Barzilai & Zohar, 2012; Mason, Boldrin, & Ariasi, 2010a), for the first research question we hypothesized that participants would not be very accurate in discerning the reliability of the websites. We also hypothesized a wide range of criteria underlying their rank-ordering, only some of which at an advanced level, that is, referred to the authoritativeness of a website and the scientific evidence supporting the claims.

For the second research question, based on the aforementioned literature (e.g., Saleminck et al., 2015), we hypothesized that the implicit association of the mobile phone with health-no health would be related to students' rank-ordering of the reliability of six websites varying for position on the issue. Specifically, the higher their associations of mobile phones with no health, the lower their scores for rank-ordering. While reading, these students may be more distracted or overwhelmed by worries evoked by text content,

which is related to the no health they implicitly associate with the use of mobile phones, and consequently, they are less able to discern between the various digital sources.

We also hypothesized that basic psychophysiological self-regulation, which indexes greater ability to self-regulate, would be related to students' rank-ordering of the websites. Specifically, the higher their HRV, the higher their accuracy in source evaluations as they are more able to self-regulate during reading emotional content, thus, they are more able to discern among the various websites.

For the third research question, besides the main effects, we hypothesized that the interaction between basal psychophysiological self-regulation and implicit associations would be related with source evaluation. Specifically, this hypothesis is based on the well-known transactional model (Bronfenbrenner & Ceci, 1994), which postulates that biology and environment combine and interact to produce complex behavioral phenotypes. We expected that the trait biological marker of self-regulation (i.e., HRV at rest) would combine and interact with students' implicit associations that have been learned from the environment (Castelli, Zogmaister, & Tomelleri, 2009). Hence, the combination of these two factors would affect students' ability to rank-order the websites accurately. In other words, students who have learned from their environment to implicitly strongly associate mobile phones with no health, would be less accurate in evaluating source reliability, particularly when their HRV is low, and vice versa.

2. Method

2.1. Participants

Participants were 72 seventh graders (32 girls) aged between 12 and 13 years living in North-eastern Italy. Initially 75 participants were involved but the data of 3 students were excluded from the analysis for high error rate in the test of implicit associations (see 2.2.1). All participants were native-born Italian and shared an upper middle class socioeconomic status. They voluntarily participated upon written parental consent. The study was approved by the University Ethics Committee.

2.2. Pre-reading measures

2.2.1. Implicit associations

We used a Single Category Implicit Association Test (SC-IAT), a methodological variation of the Implicit Association Test to measure the strength of participants' evaluative associations of mobile phone with health or no health (Karpinski & Steinman, 2006). The SC-IAT consisted in two stages, each comprising a practice task (14 trials) and a subsequent test task (42 trials). One stage assessed the mobile phone–health association, asking participants to categorize mobile phone-related words and health-related words using one key (*a*), and non-health related words using another key (*l*). The other stage assessed the opposite association (i.e., mobile phone–unhealthy), asking participants to categorize mobile phone-related words and unhealthy-related words with one key (*l*), and health-related words with another key (*a*). To prevent response biases the three categories were not presented with an equal number of words, but were presented in a 4:4:6 ratio so that 57% of correct responses were on the *a* key and 43% of correct responses were on the *l* key. The practice tasks consisted of one block of trials (14 trials), whereas the experimental tasks consisted of three blocks of 14 trials (for a total of 42 trials in each experimental task).

A pilot study ($N = 55$) was conducted in order to select the target words that best represented the categories included in the IAT. Pilot-study participants were asked to indicate on a 10-point Likert scale the extent to which each of 12 nouns was associated with “mobile phone” (1 = not at all, 10 = completely associated) and the extent to which each of 24 adjectives was associated to “health” (1 = unhealthy; 10 = healthy). We selected the 4 nouns (*battery*, *charger*, *top-up*, *SIM*) that received the higher ratings for the association with mobile phone ($M = 8.94$, $SD = 1.32$), the 6 adjectives that received the higher rating for health ($M = 7.73$; $SD = 1.77$, namely *beneficial*, *good for you*, *positive*, *healthy*, *useful*, *advantageous*) and the six adjectives that received the lower ratings for health ($M = 2.99$; $SD = 1.72$, namely *bad for you*, *unhealthy*, *negative*, *harmful*, *risky*, *unsafe*).

Each stage of the test was preceded by a set of instructions concerning the dimensions of the categorization task and the appropriate response keys. Each target word appeared centered on the screen. Category reminder labels were appropriately positioned on the top of the screen. The target word remained on the screen until the participants responded. If participants failed to respond within 1.500 ms, a reminder “Please respond more quickly!” appeared for 500 ms. In line with the original procedure proposed by Karpinski and Steinman (2006), following each response, participants were given feedback regarding the accuracy of their response. A green *O* in the center of the screen for 150 ms followed correct responses and a red *X* incorrect responses. A correct response corresponded to the correct categorization of targets words (e.g., *unsafe*) with the key corresponding to the proper category (e.g., *unhealthy*).

Data were treated following Karpinski and Steinman's original procedure (2006). Three participants with error rated higher than 20% were excluded; the average accuracy was 91.79% ($SD = 6.44$). Given that each participant responded to every trials, we had no non-responses. Responses faster than 350 ms were eliminated and error responses were replaced with the block mean plus an error penalty of 400 ms. The SC-IAT score was computed by subtracting the average response time of the block associating mobile phone with health to the average response time of the block associating mobile phone with no health. This quantity was divided by the standard deviations of all responses. Therefore, the higher the score value, the more the participants associated mobile phone with no health.

2.2.2. Psychophysiological self-regulation

It was measured by heart rate variability, which is the variation in the beat-to-beat interval. To easily obtain heart rate variability in the school context, photoplethysmography was recorded in a standardized fashion using a multi-modality physiological monitoring device that encodes biological signals in real-time (ProComp Infiniti, Thought Technology; Montreal, Canada). Photoplethysmography is a simple, non-invasive technique used to detect blood volume pulse. Photoplethysmograph sensor was attached to the index fingertip of the participant's non-dominant hand and blood volume pulse was recorded while s/he was at rest for eight minutes while watching a relaxing video of a natural scenario. Data about the inter-beat intervals were derived and artifacts were controlled. Then the time distances between each beat were exported in the Kubios-HRV 2.2 (Kuopio, Finland) software to correct artifacts with a piecewise cubic spline interpolation method that generates missing or corrupted values into the series of inter-beat intervals. Then, the number of interval differences of successive NN intervals greater than 50 ms (NN50) were calculated. Specifically, NN50 is an index sensitive to short-term fast fluctuations of heart periods. As it reflects the influence of vagal nerve on the heart (Porges, 2007), higher NN50 values indicate increased parasympathetic activity.

2.2.3. Reading comprehension

The Italian standardized test for the appropriate grade (Cornoldi & Colpo, 1995) had already been administered to the participants in a study with different aims, which included other measures that are not relevant for the current study (Mason, Scrimin, Tornatora, & Zaccoletti, 2017), as a part of a larger research project. Participants read an informational text and answered 14 multiple-choice questions. Each correct answer scored 1 point.

2.2.4. Working memory capacity

A complex Reading Span Test (Pazzaglia, Palladino, & De Beni, 2000) had already been administered to the participants as part of the aforementioned larger research project. Participants were asked to read aloud lists of unconnected sentences, to judge if each sentence was true or not, and then to recall in the correct order the final word of each sentence presented in a list. Lists were grouped on the basis of the total number of sentences included. The score corresponded to the greatest list length a participant recalled entirely in the correct order.

2.2.5. Prior knowledge

Participants had already been asked five open-ended written questions to assess their prior knowledge about the topic of the online texts, as part of the wider research project mentioned above. The questions, mostly taken from Bråten et al. (2014, p. 67), were about electromagnetism, how mobile phones work, the possible health risks related to their use and how they occur, and how researchers investigate whether mobile phones might damage health. The answers to these questions were analyzed for content and scored 1 for each correct information unit mentioned. The possible range for each question was 0–3. A random selection of 40 students' responses to the five questions were scored independently by the first and third authors, resulting in a 96% agreement for all answers. All disagreements were resolved through discussion. The same authors collaboratively scored the remaining participants' answers.

2.3. Materials

Participants read six pages taken and adapted from authentic websites with different positions on the topic of the potential health risks associated with the use of mobile phones, used in a previous study (Mason et al., 2017). Therefore, the reading materials were ecologically valid. Before reading, the participants were told: "Imagine that a friend has asked you whether using a mobile phone is dangerous to your health. You have decided to research information about the issue on the Internet, as you have already done for other topics, and you have found six websites with information about the issue. Please open and read, at least once, all the websites that you see in the Google search output page".

Different combinations of search results relative to the authoritativeness and position of the first sources were used in random order and participants read the websites in any order they liked within the combination they received. They were told that they could re-access and re-read the six webpages and had 35 min to read them. Although the webpages were stored locally by creating an offline environment, they were presented through a browser with clickable links thus appearing as a Google search output page. It is interesting to note that all participants read all six websites.

Sources contained between 355 and 398 words of text. The topic was chosen as it is relevant and engaging for young adolescents who use mobile phones daily. A group of six experts rank-ordered the six websites according to their reliability as follows:

- (1) Ministry of Health (position: mobile phones are not harmful according to current scientific knowledge);
- (2) Italian Society of Pediatrics (position: there is not scientific knowledge yet about the risks in the long term regarding children, but we know that they are more exposed, for various reasons, to potentially negative consequences of mobile phones, including carcinogenic factors. Therefore mobile phones should not be given to children and all precautions should be taken when they are used);

- (3) Melarossa, regarding nutrition and diets supervised by the physicians of the Italian association of food science (position: an intense use of cell phones may increase the risk of severe health problems and basic precautions should be taken);
- (4) a popular Italian newspaper, La Repubblica (position: mobile phones are not harmful according to current scientific evidence; however the site also mentioned European Council's concerns about Wi-Fi radiation in schools);
- (5) an unknown blogger, amateur of natural life (position: mobile phones are definitely harmful);
- (6) a global producer of infrastructures for communication technology, Ericsson (position: mobile phones are definitely harmless).

Information about the author, credentials, and date of publication (if available) of each website was provided on the top of the page. Fig. 1 shows the screenshot of an example website.



Fig. 1. Screenshot of one of the websites used.

It should be pointed out that the reading materials had an emotional content as the texts about the harmfulness of mobile phones, and the texts about their harmlessness, all mentioned various diseases, using emotionally charged words, like carcinogenic, tumor, brain cancer, intracranial tumors, and eye cancer.

2.4. Post-reading measures

2.4.1. Overall rank-ordering of the websites

After reading, participants were asked to rank-order all the six websites, from the most to the least reliable (Bråten et al., 2015), assigning the value 1 to the website judged as more reliable and the value 6 to the website judged as the least reliable. Participants were awarded 1 point for each site correctly ranked, compared to the expert rank-order (range 0–6; Mason, Junyent, & Tornatora, 2014). When rank-ordering the websites, readers did not have the opportunity to look back at the websites, but were provided with a randomized list of the sites including the URLs and a blank space in which to write the rank.

2.4.2. Justification for source evaluation

For a deeper insight into participants' source evaluation (Mason et al., 2014), they were asked to motivate their rank-ordering. They were given the following instructions: “Now that you have rank-ordered the Internet sites with information about mobile phones, you should explain why you rank-ordered the sites the way you did, and what you based your decision on. In other words, you should provide one or more justifications for rank-ordering the websites. Please concentrate on the two sites which are most and least reliable, and be as clear and complete as possible in explaining the reasons for your rank-ordering”. As we used a strict, fine-tuned comparison with the expert rating in assessing source evaluation, we sought to understand the justifications participants appealed to when rank-ordering the digital pages they read. In this regard, we focused on the two most and the two least reliable websites as they were more discernible, allowing us to understand better what was important in participants' decisions.

Justifications were analyzed qualitatively by the first and third authors. The coding system was inspired by the coding categories of Bråten, Strømsø, and Andreassen (2016). The following categories of justification were identified: *Source characteristics* (e.g., “Who wrote this site has much knowledge on the topic, so it gives trustworthy information that is based on valid studies”), *personal opinion* (e.g., “The information is credible because in my opinion in the long term cell phones are dangerous to our health”), *reference to other sources* (e.g., “Even if the other sites say that there are no scientific studies that prove the health risks, this site described the precautions to take to avoid some risks”), and *reference to the content* of the document read (e.g., “What it says about how to use the mobile phone is more interesting and useful for us”). No reference to personal experiences was identified in our sample. Inter-rater agreement was 93% on categorization. Disagreement was resolved through discussion between the two raters.

2.5. Procedure

The study comprised three sessions. In the first, as part of the wider research project mentioned above, reading comprehension, prior knowledge, and working memory had already been assessed. In the second session of this study, each participant was individually tested in a quiet room of the school to administer the Implicit Association Test. Then, their basal heart rate variability was recorded while they watched the relaxing video. In the third session of the study, in the school's computer lab, participants read the six online sources for about half an hour. After a brief filler task, they were asked to rank-order the websites and provide justifications for rank-ordering the two most, and the two least, reliable sites.

3. Results

3.1. RQ1: rank-ordering the websites and evaluation criteria

First of all, a non-parametric omnibus Friedman test revealed significant differences among the mean ranks for the six documents, $\chi^2(5, N = 72) = 27.25, p < .001$. Table 1 presents descriptive information about the reliability ranking for the six documents.

Follow-up multiple comparisons using Wilcoxon Signed Ranks test indicated that the students judged the site of the Ministry of Health (no.1) to be more reliable than the site of the newspaper (no. 4), $Z = 3.27, p = .001$ and the site of Ericsson (no. 6), $Z = 4.07, p < .001$, that is, sites considered of intermediate and low reliability, respectively, on the examined issue. Of note is that the blogger

Table 1
Descriptive information about the ranking data.

Website	<i>M</i>	<i>SD</i>	Skewness	Kurtosis
Ministry of Health	3.01	1.60	0.33	−1.03
Italian Society of Pediatrics	3.13	1.51	0.30	−0.83
Melarossa (supervised by the Association of food science)	3.13	1.67	0.12	−1.33
Repubblica (newspaper)	3.99	1.64	−0.43	−1.02
Unknown blogger	3.58	1.82	0.09	−1.48
Ericsson	4.26	1.56	−0.72	−0.50

Note. Lower means indicate more reliable sites according to the participants' rank-ordering. (1 = most reliable, 6 = least reliable).

Table 2

Frequencies and percentages of participants who ranked each website for reliability at the various positions.

Website	Positions					
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Ministry of health	16 (22.22)	16 (22.22)	12 (16.67)	13 (18.06)	9 (12.5)	6 (8.33)
Italian Society of Pediatrics	12 (16.67)	15 (20.83)	18 (25)	12 (16.67)	9 (12.5)	6 (8.33)
Melarossa	18 (25)	11 (15.28)	13 (18.06)	9 (12.5)	16 (22.22)	5 (6.94)
La Repubblica	7 (9.72)	9 (12.5)	10 (13.89)	16 (22.22)	12 (16.67)	18 (25)
Unknown blogger	10 (13.89)	17 (23.61)	11 (15.28)	7 (9.72)	9 (12.5)	18 (25)
Ericsson	6 (8.33)	6 (8.33)	8 (11.11)	13 (18.06)	21 (29.17)	18 (25)

Note. On the left-most column websites are reported in order of reliability according to the expert rank-ordering.

site (no. 5), which provided information about serious health problems caused by the use of mobile phones, was not judged as less reliable to a statistically significant extent than the site of the Ministry of Health (no.1) maintaining the harmless of mobile phones according to the current scientific research. The site of the Italian Society of Pediatrics (no. 2) was also evaluated as more reliable than the site of Ericsson (no. 6), $Z = 3.71$, $p < .001$, and the site of the newspaper (no. 4), $Z = 2.92$, $p = .002$. There were no statistically significant differences amongst the reliability rankings of the sites at intermediate (no. 3 and no. 4) and lower levels (no. 5 and no. 6) according to the expert rank-ordering. It should be pointed out that multiple comparisons were performed using Holm's sequential Bonferroni correction to protect against Type 1 error (Habdi, 2010). Specifically, the cutoff p values ranged from 0.05 to 0.003, given that 15 pairwise comparisons were performed. Table 2 reports frequencies and percentages of participants who rank-ordered each of the websites for reliability at the various positions.

Table 3

Frequencies and percentages of justifications for ranking the two most and least reliable sites.

Ministry of Health (no. 1) <i>n</i> = 16 (22.2%)		
Type of Justification	<i>F</i>	%
Source characteristics	9	45
Personal opinions	3	15
References to other sources	0	0
Reference to content	8	40
Italian Society of Pediatrics (no. 2) <i>n</i> = 15 (20.8%)		
Source characteristics	6	35.3
Personal opinions	1	5.9
References to other sources	2	11.8
Reference to content	8	47
Ericsson (no. 6) <i>n</i> = 19 (26.4%)		
Source characteristics	12	42.9
Personal opinions	6	21.4
References to other sources	0	0
Reference to content	10	35.7
Unknown blogger (no. 5) <i>n</i> = 9 (12.5%)		
Source characteristics	4	26.7
Personal opinions	3	20
References to other sources	2	13.3
Reference to content	6	40

Note. Students could refer to more than one criterion to justify their ranking. Percentages are computed on the total number of justifications given by the participants who accurately rank-ordered the sites.

We then quantified the justifications produced by students to accurately rank-order the two most and the two least reliable websites. It is interesting to note that all students provided relevant justifications for their rank-ordering, giving a total of 379. Of these justifications, 81 (21.37%) referred to the characteristics of the source, 77 (20.32%) to personal opinions, 28 (7.39%) to corroboration with other sources, and 193 (50.92%) to aspects of the content.

We then qualitatively examined the justifications. As reported above (see the Method section), according to the expert rank-ordering, the two most reliable were those of the Ministry of Health and of the Italian Society of Pediatrics, whereas the two least reliable websites were those of the blogger and Ericsson. Out of 72 readers, 22.22% accurately rank-ordered the site of the Ministry of Health as no. 1 and 20.83% the site of the Italian Society of Pediatrics as no. 2. Readers who accurately rank-ordered Ericsson's site as no. 6 were 25% and the blogger's site as no. 5 were only 12.50%. Table 3 presents descriptive data about the reasons for ranking the most and least reliable sites.

3.1.1. Justification for rank-ordering the ministry of health as the most reliable site

A Friedman test was performed to reveal possible differences in the frequency of the various justification categories used to evaluate the Ministry of Health as the most reliable website. This omnibus test showed significant differences across the categories, $X^2(3, N = 16) = 12.46, p = .006$. No students referred to other sources when justifying their rank-ordering. Contrast analyses were performed using Wilcoxon Signed Ranks test with the Holm's sequential Bonferroni correction, so the cutoff p values ranged from 0.05 to 0.008, given that 6 pairwise comparisons were performed. These non-parametric analyses revealed no statistically detectable significant differences among the justification categories. It means that the participants used different types of criteria to a substantially equally extent to motivate their judgment on this site as the most reliable, although they considered more the source characteristics than their personal opinions.

An illustrative example of justifications based on the authoritativeness of the source is the following: "In my opinion, they are competent and expert and take care of the health more than the others. Moreover, it is an organization based on the health". An example of appeal to personal opinions is: "I have the same opinion: health is fundamental and we should not take any risk". Finally, an illustrative example of justifications based on general or specific aspects of the content is: "Because it provides information based on solid data".

3.1.2. Justification for rank-ordering the site of the Italian Society of Pediatrics as a pretty reliable site

A Friedman test was performed again to reveal possible differences in the frequency of the various justification categories used to evaluate the site of Pediatrics as no. 2 in their rank-ordering. The test revealed significant differences across the categories, $X^2(3, N = 15) = 10.69, p = .013$. However, Wilcoxon Signed Ranks tests did not reveal acceptable levels of statistical significance when comparing the justification categories, although those regarding the authoritativeness of a source and general or specific aspects of the content provided were more frequent than those about personal experiences or other sources.

An illustrative example of justifications about the source authoritativeness is the following: "I trust this site a lot because they are doctors, pediatricians, they know". For the category of personal opinions, an example is: "I like the way they explain the problem". Reference to other sources is exemplified by the following example: "Some of the reported information is also provided by other sites I have read". Finally, an illustrative example of justifications based on the content is: "It provides information about the possible health risks, saying that they may be different for adults and children".

3.1.3. Justification for rank-ordering Ericsson as the least reliable site

Another Friedman test revealed statistically significant differences in the frequency of the various justification categories used to evaluate the site of Ericsson as no. 6, $X^2(3, N = 19) = 15.27, p = .002$. In their justifications, the students did not refer to other sources for corroboration. Anyway, multiple comparisons by Wilcoxon Signed Ranks tests did not reveal acceptable levels of statistical significance when comparing the justification categories, although the characteristics of the source were taken into account more than personal opinions.

An illustrative example of a justification based on the source characteristics is the following: "They are a company that sells mobile phones and equipment for telecommunication, therefore they make good advertisements not to decrease their market". The following is an example of reasons referring to personal opinions: "In my opinion it is not true that mobile phones are definitely harmless". Finally, an example of justification based on the content is: "This site only says the benefits of the use of mobile phones, but nothing about the possible health risks".

3.1.4. Justification for rank-ordering the blogger site as little reliable

Once again, a Friedman test was performed to reveal possible differences in the frequency of the various justification categories used to evaluate the site of the blogger as no. 5. This omnibus test did not reveal significant differences, $X^2(3, N = 9) = 3.38, p = .336$. When evaluating this online source, the students used all four justification categories to the same extent.

The following is an example of reference to the source features: "I do not think this is reliable as the author is a blogger". Reference to other sources is exemplified by this: "It is clearly a home-made site that gives information contrasting with what the other sites say about the question of mobile phones". An example of the criterion based on personal opinion is: "I think it is true that mobile phones might be harmful but not as much as she writes". Finally, the following is an example of reasons regarding the informational content: "The site is too tragic and only lists diseases, and does not provide recommendations about how to use the mobile phone safely".

Table 4

Descriptive statistics and zero-order correlations between individual characteristics and source evaluations (N = 72).

	1	2	3	4	5	6
1. Implicit associations	–					
2. Heart rate variability (HRV)	-0.27*	–				
3. Source evaluation	-0.25*	0.31**	–			
4. Working memory	0.06	0.10	0.22	–		
5. Reading comprehension	-0.02	0.04	0.20	0.23*	–	
6. Prior knowledge	-0.03	0.03	-0.05	0.14	0.22	–
<i>M</i>	0.17	217.65	1.15	2.08	7.19	3.51
<i>SD</i>	0.30	35.74	1.03	0.64	0.01	1.78
<i>Min</i>	-0.46	132.00	0	0	2	0
<i>Max</i>	1.10	316.00	6	5	10	7
<i>Skewness</i>	0.53	0.09	1.01	0.17	-1.02	-0.31
<i>Kurtosis</i>	0.35	0.23	0.86	1.23	0.16	-1.02

* $p < .05$, ** $p < .01$.

3.2. RQ2: correlations between implicit associations, psychophysiological self-regulation, and source evaluation

To reveal the relationships between the variables of interest, we performed correlation analyses. The score for correctly ranking all six websites (see section 2.4.1) according to the expert ranking was used for source evaluation ability. Table 4 reports descriptive statistics and correlation coefficients. Interestingly, IAT scores negatively correlated with the overall ranking of the six websites ($r = -0.25$) as well as with the psychophysiological marker ($r = -0.27$) of self-regulation (HRV). These data indicate that the more the students associated the mobile phone with no health, the lower was their ability to accurately rank-order the websites and their basal ability to emotionally self-regulate at psychophysiological level.

Moreover, HRV positively correlated with source evaluation ($r = 0.31$) as expressed in the overall ranking. This outcome revealed that the higher the participants' basal psychophysiological regulation, the greater their website ranking for reliability.

3.3. RQ3: main and interactive effects of implicit associations and psychophysiological self-regulation on source evaluation

To examine the main and interactive effects of HRV and implicit associations on source evaluation when controlling for reading comprehension, working memory, and prior knowledge, we carried out a hierarchical regression analysis. In the first step the three control variables were entered into the equation. In the second step, implicit associations (centered) and psychophysiological self-regulation (centered) were added to the equation. In the third step, the interaction term, implicit associations by self-regulation, was entered into the equation. Results of the regression analyses are reported in Table 5.

The regression model was not significant after entering the scores for reading comprehension, working memory, and prior knowledge in the first step, $R^2 = 0.09$, $F_{\text{change}}(3, 67) = 2.31$, $p = .083$. The addition of scores for IAT and HRV in the second step resulted in a statistical increase in the explained variance, $R^2 = 0.23$, $F_{\text{change}}(2, 65) = 5.65$, $p = .005$. In this step, implicit associations were a significant predictor ($\beta = -0.25$). The addition of the interaction term in the third step explained a further significant portion of variance, $R^2 = 0.31$, $F_{\text{change}}(1, 64) = 7.26$, $p = .009$. Implicit associations ($\beta = -0.35$) and self-regulation ($\beta = 0.28$) in themselves, and in interaction ($\beta = -0.31$) were significant predictors in this step.

Table 5

Results of hierarchical regression for variables predicting source evaluation (N = 72).

Predictor	R^2	<i>B</i>	<i>SE</i>	β	<i>t</i>	<i>p</i>
Model 1	0.09					
Working memory		0.37	0.19	0.23	1.92	.059
Reading comprehension		0.08	0.06	0.16	1.33	.188
Prior knowledge		-0.02	0.07	-0.03	-0.29	.767
Model 2	0.23					
Working memory		0.36	0.18	0.22	2.01	.049
Reading comprehension		0.08	0.06	0.15	1.33	.188
Prior knowledge		-0.03	0.07	-0.05	-0.45	.652
Implicit associations (IAT)		-0.86	0.38	-0.25	-2.22	.030
Heart rate variability (HRV)		0.01	0.00	0.21	1.81	.075
Model 3	0.31					
Working memory		0.34	0.17	0.21	1.97	.052
Reading comprehension		0.05	0.05	0.10	0.92	.359
Prior knowledge		-0.02	0.06	-0.04	-0.43	.663
Implicit associations (IAT)		-1.19	0.39	-0.35	-3.07	.003
Heart rate variability (HRV)		0.01	0.00	0.28	2.49	.015
IAT x HRV		-0.03	0.01	-0.31	-2.69	.009

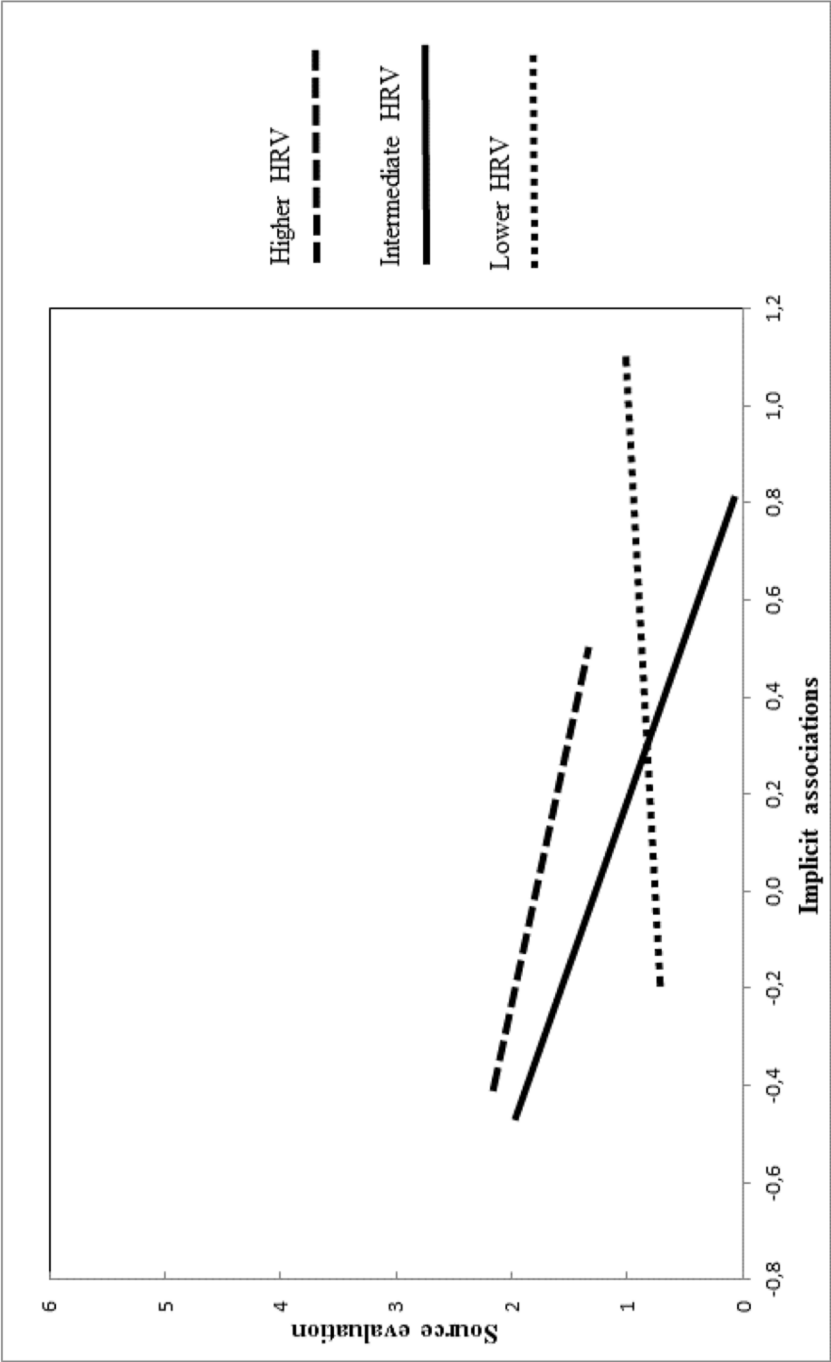


Fig. 2. Plot of the significant interaction effect of implicit associations and psychophysiological emotion regulation (HRV) on source evaluation. The higher the scores for implicit associations, the more the participants associated the cell phone with no health. Lower HRV = below the 25th percentile; intermediate HRV = from the 25th to the 75th percentile; Higher HRV = above the 75th percentile.

For a complete examination, to follow up on the significant interaction observed in the regression analysis, we performed a simple slope analysis (Aiken & West, 1991) at three different levels, considering participants below the 25th percentile, between the 25th and 75th percentile, and above the 75th percentile for psychophysiological self-regulation. The rationale for this procedure is based on two reasons. First, some studies have shown that in order to account for individual differences in psychophysiological measures, it is more informative to divide a sample into three groups instead of two (e.g., Doussard-Roosevelt, Montgomery, & Porges, 2003). Second, authors such as Aiken and West (1991), Dawson (2014), and Dawson and Richter (2006), have posited that simple slope tests are only useful for testing significance at specific values of the moderator and that whenever possible, meaningful values are to be chosen instead of just one standard deviation above and below the mean.

The slope analysis indicated that implicit associations did not significantly interact with psychophysiological self-regulation when the latter was very low (below the 25th percentile; $b = 0.22$, $SE = 0.48$, $\beta = 0.11$, $t(17) = 0.46$, $p = .647$), or very high (above the 75th percentile; $b = -0.89$, $SE = 1.62$, $\beta = -0.13$, $t(17) = -0.55$, $p = .588$). In contrast, when the psychophysiological self-regulation was in the midrange (between the 25th and 75th percentile), implicit associations were significantly related with source evaluation ($b = -1.48$, $SE = 0.61$, $\beta = -0.38$, $t(35) = -2.43$, $p = .021$). Specifically, when students' psychophysiological self-regulation was average, its combination with a stronger implicit association of the mobile phone with health contributed to a better source evaluation, while its interaction with a weaker implicit association of the mobile with health contributed to a less accurate source evaluation. Fig. 2 visualizes the results of the slope analysis.

4. Discussion

Internet source evaluation is a topical area of educational research, which has examined the role played by various factors, like topic and epistemic beliefs, and familiarity with the topic, when dealing with the issue of the authoritativeness of various conflicting informational sources on the same topic. We considered theoretically and practically significant to extend the analysis of the factors underlying source evaluation by investigating the role of more “subtle” variables. We examined implicit associations as they are less influenced by social desirability bias but still affect explicit behavior, especially in case of uncertainty (Galdi, Arcuri, & Gawronski, 2008). We also considered a psychophysiological marker of self-regulation, heart rate variability, as an objective and reliable measure of the extent to which an individual is able to adapt to the situational demands taking under control her/his emotions and thoughts, and thus generating an optimal response to meet those demands.

The first research question asked how middle-school students rank-order for reliability a set of websites about the examined topic and what evaluation criteria they used. First of all, the findings indicated that the participants were able to discriminate the two most reliable sites from a site at intermediate and a site at a low level for the same source characteristics. However, as hypothesized, participants' overall accuracy in rank-ordering the six sources was very low (mean score of 1.15 in a range 0–6). These results are in line with those indicating that middle school students do not manifest good ability in source evaluation (Barzilai & Zohar, 2012; Mason et al., 2010a).

When considering the criteria used to establishing the reliability of a website, as hypothesized, the students appealed to a wide range of justifications, specifically, the authoritativeness of the source, personal opinions, corroboration across sources, and general or specific aspects of the content provided. It means that both higher and lower level justifications were appealed to, although for the two most reliable sites reference to personal opinions were less used when establishing their reliability. Interestingly, both for the most and least reliable sites the criterion of corroboration across sites was never appealed to and the criterion of source characteristics (authoritativeness for the former and commercial bias for the latter) prevailed over reference to personal opinions, although not to a statistically detectable difference.

Even if the participants did not discern accurately all the websites in terms of reliability, they considered, at least to some extent, the trustworthiness of the information in light of the features of the sources. These findings confirm what previous research on source evaluation by middle and secondary school students have also documented (Barzilai & Zohar, 2012; Kiili et al., 2008; Mason et al., 2014). Of note is that the justification categories used for rank-ordering the sites also emerged in investigations with university students (Barzilai et al., 2015; Bråten et al., 2014, 2015).

The second research question asked whether our variables of interest, the implicit association of mobile phone with health-no health and self-regulation at the psychophysiological level (HRV at rest) were related to source evaluation, as reflected in the overall score for rank-ordering the websites. As hypothesized, significant correlations with source evaluation emerged for both variables. Specifically, the less the students implicitly associated the mobile phone with no health, the more they were accurate in rank-ordering the six digital sources. Such negative correlation can be explained, at least to some extent, by the myside bias (Perkins et al., 1991). More specifically, to exemplify considering an instance of this bias, students who more strongly associated the mobile phone with no health were also those with a tendency to judge the blogger site as very or pretty reliable. This site provided clear but scientifically unsupported information that mobile phones cause very serious health diseases. Thus, these students may have looked for confirmation of their evaluative implicit associations, ranking an unreliable site as authoritative (Stanovich et al., 2012).

Furthermore, students with higher HRV, that is greater self-regulation, were more accurate in rank-ordering the websites. As previously reported, HRV at rest is an index of both cognitive and emotional self-regulation due to its ability to reflect neural feedback mechanisms of central nervous system–autonomic nervous system integration (Friedman & Thayer, 1998). Specifically, higher HRV is associated with the ability to self-regulate, thus with greater behavioral flexibility and adaptability in a changing environment (Porges & Byrne, 1992). Therefore, the positive correlation between HRV and rank-ordering scores is aligned with this model as well as with findings from different areas of psychological research. Higher scores in this basal ability to respond to situational demands is a resource for cognitive functioning (Hansen et al., 2003; Sollers et al., 2010). This positive correlation is also

in line with our previous study on preschoolers which found a positive link between basal HRV and oral text comprehension (Scrimin, Patron, Florit, et al., 2017), as children with higher self-regulation at the beginning of the school year were better comprehenders at the end of the year.

The nature of self-regulation, as indexed by the physiological marker of HRV, which is related to both emotional and cognitive regulatory skills, makes this finding particularly interesting. In fact, both emotional and cognitive regulations are relevant to source evaluation. This is particularly true when the texts being read contain material that may cause an emotional reaction in the reader. In this case, the student needs to regulate his/her emotional response in order not to be overwhelmed by distressing emotions that may impair source evaluation. However, students also need to have adequate cognitive regulatory capacities in order to sustain and shift attention as well as select meaningful information and disregard irrelevant information from the documents read. It should be noted that information that is particularly meaningful (or that evokes emotional reactions, such as “mobile phones can cause cancer”) will attract the person's attention and resources, hence the ability to self-regulate from both an emotional and a cognitive perspective is particularly relevant.

The third research question aimed at investigating whether also the interaction between students' implicit associations and basal regulation of emotions was related to source evaluation, after controlling for the potentially interfering variables of working memory, reading comprehension, and prior knowledge. A hierarchical regression analysis revealed a significant interaction between IAT and HRV where only among students with an average HRV, implicit associations were significantly linked to website rank-ordering. Specifically, when the mobile phone was associated with health, the scores for source evaluation were better, compared with when the mobile phone was associated with no health. The interaction effect can also be read in terms of students' implicit associations. That is, when the mobile phone was related to health, students' scores for source evaluation were better, compared with when the mobile was associated with no health among students with an average HRV.

These findings suggest that it is only when students have an average psychophysiological self-regulation, which indeed is most often the case, that their implicit associations with the mobile phone are very relevant. In other words, when students have high or low psychophysiological self-regulation, their implicit evaluative associations, which are related to what they have learned from their environment about mobile phones, do not come to play in reliability judgments. An explanation for these results is that students with high self-regulation perform better despite their implicit evaluations of the mobile phone, that is, their ability to self-regulate allows them to judge informational sources correctly despite what they have learned from the environment. At the other extreme, low self-regulation readers evaluate sources less correctly. These students do not perform well and their implicit association does not support them enough in order to make significantly more accurate evaluations. This is in line with the existing literature which links higher basal HRV with better performance, and low self-regulation with poor performance, in tasks assessing cognitive and executive functioning (such as working memory and inhibitory control) in pre-school and school-aged children as well as undergraduate students (Gillie, Vasey, & Thayer, 2014; Marcovitch et al., 2010; Staton, El-Sheikh, & Buckhalt, 2009). Only among readers with intermediate level psychophysiological self-regulation, as indexed by basal heart rate variability, does the psychophysiological correlate accumulate with what they have learned from their experiences, and both aspects interact in predicting their performance in source evaluation.

In sum, this study contributes uniquely to research on source evaluation in middle school students. It reveals that implicit associations are related to judgments about the reliability of informational sources on the Internet and may lead to the myside or confirmation bias. Furthermore, the study emphasizes the importance of the accumulation of both biological and environmental factors in predicting how students evaluate the reliability of multiple websites.

4.1. Limitations

When interpreting these findings, however, some limitations should be taken into account. First, as a measure of source evaluation skill, we only used a fine-tuned comparison of participants' rank-ordering and expert rank-ordering. This comparison may have underestimated participants' ability to discern between high, moderate, and low-reliability sites. In future studies with young adolescents more measures of source evaluation performance should be used, including process measures, such as reading time on the various websites, for more solid data. Second, we considered only one topic, which limits the generalizability of the data. Next research should include more topics varying for emotional engagement to examine more deeply the role of self-regulation of emotions. A third limitation to overcome in future work is that we measured only psychophysiological self-regulation at rest. It will represent a more complete step forward to consider cardiac activity not only at rest but also during cognitive effort, that is, during the reading of Internet sources, for a better exploration of an ability that in itself is related to greater performance. A fourth limitation is also the lack of data from other sources to complement the psychophysiological index. A combination of objective micro-level psychophysiological measures with self-report measures of self-regulation, for example, will provide more solid data. Moreover, to overcome a fifth limitation future research should also include an explicit measure of attitudes toward the target object. Furthermore, contextual factors, for instance time constraints, are to be taken into consideration as they may influence the process of source evaluation.

4.2. Theoretical and educational significance

Despite these limitations our results add to the literature by giving relevant theoretical hints on the predictive role of the interaction of two factors – implicit associations and psychophysiological regulation of emotions – for source evaluation when reading online conflicting information on the same topic. Implicit associations are little subject to social desirability and influence

explicit behavior in a subtle way, thus measuring them is advantageous. Measuring psychophysiological self-regulation is also useful to obtain objective data about an essential ability for cognitive functioning, including academic achievement. It is also relatively easy and inexpensive to acquire indices of cardiac activity in school contexts, especially since recently smartphone applications have been developed to register heart rate and heart rate variability with the use of simple wristbands. From a theoretical perspective it is important the interaction that emerged between implicit associations and psychophysiological self-regulation when judging source reliability, with the cumulative effects of the two being a significant factor. This outcome leads to highlight how both biological markers and environmental influences may together contribute to students' evaluation of website reliability.

The study has also practical significance for the educational implications that can be drawn not only to improve the evaluation of Internet sources, a crucial ability in the Internet era, but on a broader level of school learning and achievement. We have examined two individual characteristics that are modifiable, at least to some extent, by effective interventions. Implicit associations are learned co-occurrences present in the context individuals are exposed to. In areas other than educational, research has already documented that implicit associations are changeable (e.g., Clerkin & Teachman, 2010; Suitner, Maass, & Ronconi, 2017). Therefore, in case of students' strong implicit associations with a particular object, which can act as an obstacle for executing complex tasks well, or for achievement in general, carefully designed trainings can be implemented to modify maladaptive implicit associations. For example, the exposure to counter-attitudinal material can result in a reduced strength of the original implicit association (Olson & Fazio, 2006).

Moreover, self-regulation can also be successfully trained in the school context. There are several possible interventions that can be implemented with students. Some are classroom programs that are mainly behaviorally based and aim to teach both teachers (Fried, 2011) and students emotional and cognitive strategies to help the latter to self-regulate and deal better with their affective states (Davis & Levine, 2013). Other interventions can be based on more specific HRV biofeedback trainings. During these trainings, children may learn to improve their self-regulation by receiving feedback and positive reinforces by a system registering their heart rate variability (McCraty, 2005). As already pointed out, electronic devices to monitor cardiac reactivity are inexpensive, like those used when playing sports. Thus, even apparently sophisticated techniques are affordable and usable in the school context to complement the more usual, within a frame of productive and fruitful collaboration between teachers and researchers to improve students' cognitive performance, achievement, and well-being.

Acknowledgment

This work was supported by a grant to the first author under the project 'Cognition and Emotion in Processing, Evaluation, and Comprehension of Online Conflicting Information: A Multi-Method Approach' (CPDA158418) from the University of Padova, Italy.

The authors are very grateful to all the students, their parents and teachers, and the school principals, who made this study possible.

References

- Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. Thousand Oaks, CA: Sage Publications.
- Barzilai, S., Tzadok, E., & Eshet-Alkalai, Y. (2015). Sourcing while reading divergent expert accounts: Pathways from views of knowing to written argumentation. *Instructional Science*, 43, 737–766. <http://dx.doi.org/10.1007/s11251-015-9359-4>.
- Barzilai, S., & Zohar, A. (2012). Epistemic thinking in action: Evaluating and integrating online sources. *Cognition and Instruction*, 30, 39–85. <http://dx.doi.org/10.1080/07370008.2011.636495>.
- Becker, D. R., Carrere, S., Siler, C., Jones, J., Bowie, B., & Cooke, C. (2012). Autonomic regulation on the Stroop predicts reading achievement in school age children. *Mind, Brain, and Education*, 6, 10–18. <http://dx.doi.org/10.1111/j.1751-228X.2011.01130.x>.
- Braasch, J. L. G., Bråten, I., Britt, M. A., Steffens, E., & Strømso, H. I. (2014). Sensitivity to inaccurate argumentation in health news articles: Potential contributions of readers' topic and epistemic beliefs. In D. N. Rapp, & J. L. G. Braasch (Eds.), *Processing inaccurate information: Theoretical and applied perspectives from cognitive science and the educational sciences* (pp. 117–137). Cambridge, MA: MIT Press.
- Braasch, J. L. G., Rouet, J.-F., Vibert, N., & Britt, M. A. (2012). Readers' use of source information in text comprehension. *Memory & Cognition*, 40, 450–465. <http://dx.doi.org/10.3758/s13421-011-0160-6>.
- Brand-Gruwel, S., & Stadler, M. (2011). Solving information-based problems: Evaluating sources and information. *Learning and Instruction*, 21, 175–179. <http://dx.doi.org/10.1016/j.learninstruc.2010.02.008>.
- Brand-Gruwel, S., Wopereis, I., & Vermetten, Y. (2005). Information problem solving by experts and novices: Analysis of a complex cognitive skill. *Computers in Human Behavior*, 21, 487–508. <http://dx.doi.org/10.1016/j.chb.2004.10.005>.
- Bråten, I., Braasch, J. L. G., Strømso, H. I., & Ferguson, L. E. (2015). Establishing trustworthiness when students read multiple documents containing conflicting scientific evidence. *Reading Psychology*, 36, 315–349. <http://dx.doi.org/10.1080/02702711.2013.864362>.
- Bråten, I., Ferguson, L. E., Strømso, H. I., & Anmarkrud, Ø. (2014). Students working with multiple conflicting documents on a scientific issue: Relations between epistemic cognition while reading and sourcing and argumentation in essays. *British Journal of Educational Psychology*, 84, 58–85. <http://dx.doi.org/10.1111/bjep.12005>.
- Bråten, I., Salmerón, L., & Strømso, H. I. (2016). Who said that? Investigating the Plausibility-Induced Source Focusing assumption with Norwegian undergraduate readers. *Contemporary Educational Psychology*, 46, 253–262. <http://dx.doi.org/10.1016/j.cedpsych.2016.07.004>.
- Bronfenbrenner, U., & Ceci, S. J. (1994). Nature-nurture reconceptualized in developmental perspective: A bioecological model. *Psychological Review*, 101, 568–586. <http://dx.doi.org/10.1037/0033-295X.101.4.568>.
- Castelli, L., Zogmaister, C., & Tomelleri, S. (2009). The transmission of racial attitudes within the family. *Developmental Psychology*, 45, 586. <http://dx.doi.org/10.1037/a0014619>.
- Clerkin, L. M., & Teachman, B. A. (2010). Training implicit social anxiety associations: An experimental intervention. *Journal of Anxiety Disorders*, 24, 300–308. doi:10.1016/j.janxdis.2010.01.001.
- Coiro, J., Knobel, M., Lankshear, C., & Leu, D. J. (2008). *Handbook of research on new literacies*. Mahwah, NJ: Lawrence Erlbaum.
- Cornoldi, C., & Colpo, G. (1995). *Nuove prove MT per la scuola media [New MT tests of reading comprehension for the middle school]*. Florence, Italy: Organizzazioni Speciali.
- Cunningham, W. A., & Zelazo, P. D. (2007). Attitudes and evaluations: A social cognitive neuroscience perspective. *Trends in Cognitive Sciences*, 11, 97–104. <http://dx.doi.org/10.1016/j.tics.2006.12.005>.
- Davis, E. L., & Levine, L. J. (2013). Self-strategies that promote learning: Reappraisal enhances children's memory for educational information. *Child Development*, 84,

- 361–374. <http://dx.doi.org/10.1111/j.1467-8624.2012.01836.x>.
- Dawson, J. F. (2014). Moderation in management research: What, why, when and how. *Journal of Business and Psychology*, 29, 1–19. <http://dx.doi.org/10.1007/s10869-013-9308-7>.
- Dawson, J. F., & Richter, A. W. (2006). Probing three-way interactions in moderated multiple regression: Development and application of a slope difference test. *Journal of Applied Psychology*, 91, 917–926. <http://dx.doi.org/10.1037/0021-9010.91.4.917>.
- De Houwer, J. (2006). What are implicit measures and why are we using them? In R. W. Wiers, & A. W. Stacy (Eds.). *The handbook of implicit cognition and addiction* (pp. 11–28). Thousand Oaks, CA: Sage.
- Doussard-Roosevelt, J. A., Montgomery, L. A., & Porges, S. W. (2003). Short-term stability of physiological measures in kindergarten children: Respiratory sinus arrhythmia, heart period, and cortisol. *Developmental Psychobiology*, 43, 230–242. <http://dx.doi.org/10.1002/dev.10136>.
- Fried, L. (2011). Teaching teachers about emotion regulation in the classroom. *Australian Journal of Teacher Education (Online)*, 36(3), 1–11.
- Friedman, B. H., & Thayer, J. F. (1998). Anxiety and autonomic flexibility: A cardiovascular approach. *Biological Psychology*, 47, 243–267. [http://dx.doi.org/10.1016/S0301-0511\(97\)00027-6](http://dx.doi.org/10.1016/S0301-0511(97)00027-6).
- Galdi, S., Arcuri, L., & Gawronski, B. (2008). Automatic mental associations predict future choices of undecided decision-makers. *Science*, 321(5892), 1100–1102.
- Gillie, B. L., Vasey, M. W., & Thayer, J. F. (2014). Heart rate variability predicts control over memory retrieval. *Psychological Science*, 25, 458–465. <http://dx.doi.org/10.1177/0956797613508789>.
- Goldman, S. R., Braasch, J. L. G., Wiley, J., Graesser, A. C., & Brodowska, K. (2012). Comprehending and learning from Internet sources: Processing patterns of better and poorer learners. *Reading Research Quarterly*, 47, 356–381. <http://dx.doi.org/10.1002/RRQ.027>.
- Greenwald, A. G., & Banaji, M. R. (1995). Implicit social cognition: Attitudes, self-esteem, and stereotypes. *Journal of Personality and Social Psychology*, 102, 4–27. <http://dx.doi.org/10.1037/0033-295X.102.1.4>.
- Greenwald, A. G., Banaji, M. R., & Nosek, B. A. (2015). Statistically small effects of the Implicit Association Test can have societally large effects. *Journal of Personality and Social Psychology*, 108, 553–561. <http://dx.doi.org/10.1037/pspa0000016>.
- Greenwald, A. G., McGhee, D. E., & Schwartz, J. L. K. (1998). Measuring individual differences in implicit cognition: The Implicit Association Test. *Journal of Personality and Social Psychology*, 74, 1464–1480. <http://dx.doi.org/10.1037/0022-3514.74.6.1464>.
- Gross, J. L. (1998). The emerging field of emotion regulation. *Review of General Psychology*, 2, 271–299. <http://dx.doi.org/10.1037/1089-2680.2.3.271>.
- Habdi, H. (2010). Holms' sequential Bonferroni procedure. In N. Salkind (Ed.). *Encyclopedia of research design* (pp. 1–8). Thousand Oaks, CA: Sage.
- Hansen, A. L., Johnsen, B. H., & Thayer, J. F. (2003). Vagal influence on working memory and attention. *International Journal of Psychophysiology*, 48, 263–274. [http://dx.doi.org/10.1016/S0167-8760\(03\)00073-4](http://dx.doi.org/10.1016/S0167-8760(03)00073-4).
- Hwang, G.-J., Tsai, P.-S., Tsai, C.-C., & Tseng, J. C. R. (2008). A novel approach for assisting teachers in analyzing student web-searching behaviors. *Computers & Education*, 51, 926–938. <http://dx.doi.org/10.1016/j.compedu.2007.09.01>.
- Kammerer, Y., Bråten, I., Gerjets, P., & Strømso, H. I. (2013). The role of Internet-specific epistemic beliefs in laypersons' source evaluations and decisions during Web search on a medical issue. *Computers in Human Behavior*, 29, 1193–1203. <http://dx.doi.org/10.1016/j.chb.2012.10.012>.
- Kammerer, Y., Meier, N., & Stahl, E. (2016). Fostering secondary-school students' intertext model formation when reading a set of websites: The effectiveness of source prompts. *Computers & Education*, 102, 52–64. <http://dx.doi.org/10.1016/j.compedu.2016.07.001>.
- Karpinski, A. K., & Steinman, R. B. (2006). The Single category implicit association test as a measure of implicit social cognition. *Journal of Personality and Social Psychology*, 91, 16–32. <http://dx.doi.org/10.1037/0022-3514.91.1.16>.
- Kemps, E., Tiggemann, M., Martin, R., & Elliott, M. (2013). Implicit approach–avoidance associations for craved food cues. *Journal of Experimental Psychology: Applied*, 19, 30–38. <http://dx.doi.org/10.1037/a0031626>.
- Kiili, C., Laurinen, L., & Marttunen, M. (2008). Students evaluating Internet sources: From versatile evaluators to uncritical readers. *Journal of Educational Computing Research*, 39, 75–95.
- Klapp, A. (2016). The importance of self-regulation and negative emotions for predicting educational outcomes – Evidence from 13-year olds in Swedish compulsory and upper secondary school. *Learning and Individual Differences*, 52, 29–38. <http://dx.doi.org/10.1016/j.lindif.2016.10.013>.
- Kobayashi, K. (2014). Students' consideration of source information during the reading of multiple texts and its effect on intertextual conflict resolution. *Instructional Science*, 42, 183–205. <http://dx.doi.org/10.1007/s11251-013-9276-3>.
- Kreibitz, S., & Gendolla, G. H. E. (2014). Autonomic nervous system measurement of emotion in education and achievement settings. In R. Pekrun, & L. Linnenbrink-Garcia (Eds.). *International handbook of emotions in education* (pp. 625–642). New York: Routledge.
- Kuhn, D., & Udell, W. (2007). Coordinating own and other perspectives in argument. *Thinking & Reasoning*, 13, 90–104. <http://dx.doi.org/10.1080/13546780600625447>.
- Lenhart, A. (2015). *Teens, social media & technology*. Pew Research Center. Retrieved from <http://www.pewinternet.org/2015/04/09/teens-social-media-technology-2015/>.
- Li, Z., Snieder, H., Su, S., Ding, X., Thayer, J. F., Treiber, F. A., et al. (2009). A longitudinal study in youth of heart rate variability at rest and in response to stress. *International Journal of Psychophysiology*, 73, 212–217. <http://dx.doi.org/10.1016/j.ijpsycho.2009.03.002>.
- Marcovitch, S., Leigh, J., Calkins, S. D., Leerkes, E. M., O'Brien, M., & Blankson, A. N. (2010). Moderate vagal withdrawal in 3.5-year-old children is associated with optimal performance on executive function tasks. *Developmental Psychobiology*, 52, 606–608. <http://dx.doi.org/10.1002/dev.20462>.
- Mason, L., Ariasi, N., & Boldrin, A. (2011). Epistemic beliefs in action: Spontaneous reflections about knowledge and knowing during online information searching and their influence on learning. *Learning and Instruction*, 21, 137–151. <http://dx.doi.org/10.1016/j.learninstruc.2010.01.001>.
- Mason, L., Boldrin, A., & Ariasi, N. (2010a). Epistemic metacognition in context: Evaluating and learning online information. *Metacognition and Learning*, 5, 67–90. <http://dx.doi.org/10.1007/s11409-009-9048-2>.
- Mason, L., Boldrin, A., & Ariasi, N. (2010b). Searching the Web to learn about a controversial topic: Are students epistemically active? *Instructional Science*, 38, 607–633. <http://dx.doi.org/10.1007/s11251-008-9089-y>.
- Mason, L., Junyent, A. A., & Tornatora, M. C. (2014). Epistemic evaluation and comprehension of web-source information on controversial science-related topics: Effects of a short-term instructional intervention. *Computers & Education*, 76, 143–157. <http://dx.doi.org/10.1016/j.compedu.2014.03.016>.
- Mason, L., Scrimin, S., Tornatora, M. C., & Zaccoletti, S. (2017). Emotional reactivity and comprehension of multiple online texts. *Learning and Individual Differences*, 58, 10–21. <http://dx.doi.org/10.1016/j.lindif.2017.07.002>.
- McCarty, R. (2005). Enhancing emotional, social, and academic learning with heart rhythm coherence feedback. *Biofeedback*, 33, 130–134.
- McCruden, M. T., Stenseth, T., Bråten, I., & Strømso, H. I. (2016). The effects of topic familiarity, author expertise, and content relevance on Norwegian students' document selection: A mixed methods study. *Journal of Educational Psychology*, 108, 147–162. <http://dx.doi.org/10.1037/edu0000057>.
- Nyklicek, I., Thayer, J. F., & van Doornen, L. J. P. (1997). Cardiorespiratory differentiation of musically-induced emotions. *Journal of Psychophysiology*, 11, 780–790.
- Olson, M. A., & Fazio, R. H. (2006). Reducing automatically activated racial prejudice through implicit evaluative conditioning. *Personality and Social Psychology Bulletin*, 32, 421–433. <http://dx.doi.org/10.1177/0146167205284004>.
- Pazzaglia, F., Palladino, P., & De Beni, R. (2000). Presentazione di uno strumento per la valutazione della memoria di lavoro verbale e sua relazione con i disturbi della comprensione [An instrument to evaluate verbal working memory and its relationship with comprehension difficulties]. *Psicologia Clinica Dello Sviluppo*, 3, 465–486.
- Perkins, D. N., Farady, M., & Bushey, B. (1991). Everyday reasoning and the roots of intelligence. In J. Voss, D. N. Perkins, & J. Segal (Eds.). *Informal reasoning* (pp. 83–105). Hillsdale, NJ: Lawrence Erlbaum.
- Porges, S. W. (1991). Vagal tone: An autonomic mediator of affect. In J. Garber, & K. A. Dodge (Eds.). *The development of emotion regulation and dysregulation* (pp. 111–128). New York, NY: Cambridge University Press.
- Porges, S. W. (1992). Autonomic regulation and attention. In B. A. Campbell, H. Hayne, & R. Richardson (Eds.). *Attention and information processing in infants and adults* (pp. 201–223). Hillsdale, NJ: Erlbaum.
- Porges, S. W. (2007). A phylogenetic journey through the vague and ambiguous Xth cranial nerve: A commentary on contemporary heart rate variability research.

- Biological Psychology, 74, 301–307. <http://dx.doi.org/10.1016/j.biopsycho.2006.08.007>.
- Porges, S. W., & Byrne, E. A. (1992). Research methods for measurement of heart rate and respiration. *Biological Psychology*, 34, 93–130. [http://dx.doi.org/10.1016/0301-0511\(92\)90012-J](http://dx.doi.org/10.1016/0301-0511(92)90012-J).
- Richards, J. E., & Casey, B. J. (1992). Development of sustained visual attention in the human infant. In B. Campbell, H. Hayne, & R. Richardson (Eds.). *Attention and information processing in infants and adults: Perspectives from human and animal research* (pp. 30–60). Hillsdale, NJ: Erlbaum.
- Richter, T. (2015). Validation and comprehension of text information: Two sides of the same coin. *Discourse Processes*, 52, 337–352. <http://dx.doi.org/10.1080/0163853X.2015.1025665>.
- Richter, T., & Maier, J. (2016). Comprehension of multiple documents with conflicting information: A two-step model validation. *Educational Psychologist*, 52, 148–166. <http://dx.doi.org/10.1080/00461520.2017.1322968>.
- Rouet, J.-F., & Britt, M. A. (2011). Relevance processes in multiple document comprehension. In M. T. McCrudden, J. P. Magliano, & G. Schraw (Eds.). *Text relevance and learning from text* (pp. 19–52). Greenwich, CT: Information Age Publishing.
- Rouet, J.-F., Ros, C., Goumi, A., Macedo-Rouet, M., & Dinet, J. (2011). The influence of surface and deep cues on primary and secondary school students' assessment of relevance in web menus. *Learning and Instruction*, 21, 205–219. <http://dx.doi.org/10.1016/j.learninstruc.2010.02.007>.
- Salemink, E., van Lier, P. A. C., Meeus, W., Raaijmakers, S. F., & Wiers, R. W. (2015). Implicit alcohol–relaxation associations in frequently drinking adolescents with high levels of neuroticism. *Addictive Behaviors*, 45, 8–13. <http://dx.doi.org/10.1016/j.addbeh.2015.01.002>.
- Scrimin, S., Patron, E., Florit, E., Palomba, D., & Mason, L. (2017a). The role of cardiac vagal tone and inhibitory control in pre-schoolers' listening comprehension. *Developmental Psychobiology*, 59, 970–975.
- Scrimin, S., Patron, E., Ruli, E., Pagui, C. E. K., Altoè, G., & Mason, L. (2017b). *Dynamic psychophysiological correlates of a learning from text episode in relation to reading goals*.
- Sollers, J. J., Naumann, E., Sienbenbrock, A., Hill, L. K., & Thayer, J. F. (2010). *Autonomic regulation and the attentional network task in European and American college students*. Paper presented at the 50th annual meeting of the Society for Psychophysiological Research, (Portland, OR).
- Stanovich, K. E., West, R. F., & Toplak, M. E. (2012). In V. F. Reyna, S. B. Chapman, M. R. Dougherty, & J. Confrey (Eds.). *The adolescent brain: Learning, reasoning, and decision making* (pp. 337–378). Washington, DC: American Psychological Association.
- Staton, L., El-Sheikh, M., & Buckhalt, J. A. (2009). Respiratory sinus arrhythmia and cognitive functioning in children. *Developmental Psychobiology*, 51, 149–258. <http://dx.doi.org/10.1002/dev.20361>.
- van Strien, J. L. H., Kammerer, Y., Brand-Gruwel, S., & Boshuizen, H. P. A. (2016). How attitude strength biases information processing and evaluation on the web. *Computers in Human Behavior*, 60, 245–252. <http://dx.doi.org/10.1016/j.chb.2016.02.057>.
- Strømso, H. I., Bråten, I., & Britt, M. A. (2010). Reading multiple texts about climate change: The relationship between memory for sources and text comprehension. *Learning and Instruction*, 20, 192–204. <http://dx.doi.org/10.1016/j.learninstruc.2009.02.001>.
- Strømso, H. I., Bråten, I., Britt, A. M., & Ferguson, L. E. (2013). Spontaneous sourcing among students reading multiple documents. *Cognition and Instruction*, 31, 176–203. <http://dx.doi.org/10.1080/07370008.2013.769994>.
- Suitner, C., Maass, A., & Ronconi, L. (2017). From spatial to social asymmetry spontaneous and conditioned associations of gender and space. *Psychology of Women Quarterly*, 41, 46–64.
- Thayer, J. F., Friedman, B. H., Borkovec, T. D., Johnsen, B. H., & Molina, S. (2000). Phasic heart period to cued threat and non-threat stimuli in generalized anxiety disorder. *Psychophysiology*, 37, 361–368. <http://dx.doi.org/10.1017/S0048577200982192>.
- Thayer, J. F., Hansen, A. L., Saus-Rose, E., & Johnsen, B. J. (2009). Heart rate variability, prefrontal neural function, and cognitive performance: The neurovisceral integration perspective on self-regulation, adaptation, and health. *Annals of Behavioral Medicine*, 37, 141–153. <http://dx.doi.org/10.1007/s12160-009-9101-z>.
- Thayer, J. F., & Lane, R. D. (2000). A model of neurovisceral integration in emotion regulation and dysregulation. *Journal of Affective Disorders*, 61, 201–216. [http://dx.doi.org/10.1016/S0165-0327\(00\)00338-4](http://dx.doi.org/10.1016/S0165-0327(00)00338-4).
- Tu, Y. W., Shih, M., & Tsai, C.-C. (2008). Eighth graders' web searching strategies and outcomes: The role of task types, web experiences and epistemological beliefs. *Computers & Education*, 51, 1142–1153. <http://dx.doi.org/10.1016/j.compedu.2007.11.003>.
- Walraven, A., Brand-Gruwel, S., & Boshuizen, H. P. A. (2009). How students evaluate information and sources when searching the World Wide Web for information. *Computers & Education*, 52, 234–246. <http://dx.doi.org/10.1016/j.compedu.2008.08.003>.
- Wiley, J., Goldman, S. R., Graesser, A. C., Sanchez, C. A., Ash, I. K., & Hemmerich, J. A. (2009). Source evaluation, comprehension, and learning in Internet science inquiry tasks. *American Educational Research Journal*, 46, 1060–1106. <http://dx.doi.org/10.3102/0002831209333183>.