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Journal

Journal of Clinical and Experimental Neuropsychology, 43(1)

ISSN

1380-3395

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Publication Date

2021-01-02

DOI

10.1080/13803395.2020.1851355

Peer reviewed

HHS Public Access

Author manuscript

J Clin Exp Neuropsychol. Author manuscript; available in PMC 2022 February 01.

Published in final edited form as:

J Clin Exp Neuropsychol. 2021 February ; 43(1): 1–14. doi:10.1080/13803395.2020.1851355.

Misattributions of the Source of Health-Related Information in HIV Disease

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Abstract

Introduction: Growing access to both legitimate and dubious sources of health information makes accurate source memory increasingly important, yet it may be negatively impacted by conditions that impair prefrontal functioning, including HIV. This study hypothesized that instructions supporting source encoding on a health-related memory task would disproportionately benefit source memory of people with HIV (PWH), and to examine the pattern of source memory errors that are observed.

Method: 102 individuals (61 HIV+, 41 HIV−) completed comprehensive neurobehavioral (including health literacy) and neuromedical evaluations, and were randomly assigned to one of two conditions for a health-related memory task: *Attend to Source Instructions* explicitly participants to attend to the source of health statements presented to them, which were either health professionals or lay-persons, whereas no such instruction was provided in a *Control Instructions* condition.

Results: There was no significant interaction of HIV status by condition or main effect of HIV (*p*s>.05). There was a main effect of condition whereby those who received Attend to Source Instructions performed better on item-corrected source memory than those in the Control Instructions condition (*p*=.04). Those who received Control Instructions were more likely to misattribute the source of the health information to a health professional when the correct source was a lay-person (Cohen's *d*=−0.53), which was correlated with poorer overall cognitive performance (*p*=.008) and performance-based measures of health literacy (*p*s<.05).

Conclusions: Given that people are rarely reminded to attend to the source of new health information in the real world, the risk for misattributing health information to a qualified health professional in the absence of such instructions raises the concern that people may readily incorporate questionable health recommendations into their health regimen, particularly among

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Disclosure of Interest
The authors and members of the HIV Neurobehavioral Research Program (HNRP) Group report no conflict of interest.

persons with poorer cognitive functioning and lower levels of health literacy. This may have significant downstream health consequences such as drug interactions, side effects, and inefficacy.

Keywords

Memory; Health Literacy; Health-Related Behavior; Human Immunodeficiency Virus

INTRODUCTION

In today's information-laden and technology-enabled world, health information is more widely available to patients than ever before. Such easy and immediate access to a wealth of health-related information puts a considerable burden on the patient to navigate through large amounts of material to evaluate its authenticity and safety before incorporating recommended practices into their health regimen. A critical aspect of understanding and applying health knowledge is the ability to remember its source (i.e., from where or whom the information comes), particularly given that sources will vary in terms of their accuracy. Common sources of health information can include experts (e.g., physicians, specialists, and pharmacists), the media (e.g., internet, television or print, including blogs, series, and books), and social networks (e.g., friends, family). If a patient has received information from a physician about a diagnosis, then searched for information about the condition from various websites at home, talked about the diagnosis with friends, and also watched a documentary about the condition, it could be difficult to later recall which pieces of information came from which source.

The considerable challenge of remembering the source of health-related information in the hypothetical scenario above is supported by theories of source memory, which describes one's ability to recall the characteristics, conditions, or context related to a particular episodic memory. Source memory is distinct from item memory, which refers to the specific information (e.g., health information) that is to be remembered (Glisky, Polster, & Routhieaux, 1995). In this case, source memory is the ability to recall the source of health information, or more likely, numerous different sources for several pieces of health information (e.g., physician, websites, friends, documentary). That is, a patient may accurately recall health facts or recommendations (item memory) without being able to recall the source, or the patient may misattribute the information to an incorrect source. This could be problematic or even dangerous if a patients' confidence in the veracity of health information is misguided by the fact that they have misattributed information from a dubious source of health information (e.g., an unreliable website) to a health provider.

Attending to the source of health information may be especially important to patients with chronic diseases who commonly seek information about their disease course, treatment side effects, comorbid conditions, and so on. Conditions with adverse effects on the structure and function of the prefrontal networks may be at particular risk for misattributing the source of health information. Source memory tends to be more strongly associated with prefrontal networks function than medial-temporal structures because of its reliance on self-initiated, strategic encoding and retrieval for binding the item and contextual features to perform accurate source recall (Janowsky, Shimamura, & Squire, 1989; Mitchell & Johnson, 2009).

The notion that source memory is dependent on the integrity of the prefrontal networks, particularly the dorsolateral pre-frontal cortex, is supported by studies showing single item-source dissociation in several populations with prefrontal systems dysfunction (Glisky et al., 1995; Pirogovsky et al., 2007), and across studies using multiple modalities (e.g., neuropsychological data, neuroimaging) (Baldo, Delis, Kramer, & Shimamura, 2002; Craik, Morris, Morris, & Loewen, 1990; Dobbins, Simons, & Schacter, 2004; Glisky et al., 1995; Glisky, Rubin, & Davidson, 2001; Lundstrom, Ingvar, & Petersson, 2005; Slotnick, Moo, Segal, & Hart, 2003).

Poor source memory is evident among people with HIV (PWH), who commonly show dysregulation of prefrontal systems and related deficits in learning and memory, which are characterized by problems with the strategic aspects of encoding and retrieval (Carey et al., 2006). In fact, PWH have been shown to have deficient source memory for both verbal and visual modalities (Babicz, Sheppard, Morgan, & Paul Woods, 2019; Morgan et al., 2009). Our group previously reported that PWH were moderately impaired on both verbal and visual source memory tasks relative to a demographically-similar HIV− comparison group (Cohen’s $d = 0.44 – 0.50$) (Morgan et al., 2009). A recent study found that PWH with intact global cognition were twice as likely to have source memory impairment relative to their HIV− counterparts, and PWH with HIV-associated neurocognitive disorder were four times more likely to demonstrate source memory impairment (Babicz et al., 2019). Among PWH, source memory deficits are associated with executive dysfunction (Morgan et al., 2009) and poor everyday functioning (Babicz et al., 2019).

Although little is known about source memory for health information specifically, it is established that memory plays an important role in health literacy and health behavior in HIV. Health literacy is a complex phenomenon involving access, understanding, and application of health knowledge, encompassing patient-provider communication, patient engagement with non-provider sources of health information, and an individual’s cognitive abilities (Sorensen et al., 2012). Low health literacy is related to numerous negative outcomes, including greater hospitalizations, reduced utilization of preventative medicine, and non-adherence to prescribed medications (Berkman, Sheridan, Donahue, Halpern, & Crotty, 2011). Among PWH specifically, low health literacy is associated with reduced knowledge of HIV disease (Hicks, Barragan, Franco-Paredes, Williams, & del Rio, 2006), refusal of HIV testing (Barragan et al., 2005), poorer health-related decision-making (Doyle et al., 2016), lower self-efficacy for healthcare provider interactions (Morgan et al., 2019), worse online health management (Woods et al., 2016; Woods & Sullivan, 2019), medication nonadherence (Kalichman, Ramachandran, & Catz, 1999), and missed clinic visits (Fazeli, Woods, Gakumo, Mugavero, & Vance, 2019). Low health literacy in PWH is also associated with deficits in episodic memory, attention/working memory and verbal fluency (Morgan et al., 2015), as well as executive functions (e.g., mental flexibility, sequencing, and organization; (Waldrop-Valverde, Jones, Gould, Kumar, & Ownby, 2010). HIV-associated deficits in episodic memory and executive functions are also among the strongest and most reliable predictors of health-related behaviors (Hinkin et al., 2002; Woods et al., 2009).

Given that source memory appears to be dependent upon strategic encoding and retrieval (i.e., involving both memory and executive functions), it is likely that source memory would be associated with lower health literacy. Only one prior study to date has evaluated source memory for health information. McDaniel and colleagues (2014) presented statements of medical information (item memory), each of which was paired to one of three sources (i.e., statements were paired a picture of a newspaper, a doctor, or a “friend”) to a sample of older adults and assessed their memory for both the statements and the source. This study evaluated whether a cognitive intervention (alone or paired with aerobic exercise) focused on attentional control, prospective memory, and recollection would improve performance over time. Notably, the intervention did not enhance source memory for health information over time (McDaniel et al., 2014), suggesting that a different approach to enhancing source memory is required.

Directly supporting the encoding of source information (i.e., to facilitate binding of item and source memory) may be a viable target to enhance health-related source memory recall. Strategic encoding appears to be particularly important for intact source memory, as evidenced by comparing the results of studies with different task instructions that manipulate encoding demands. Specifically, when Glisky and colleagues (2001) provided task instructions that explicitly encouraged memory for source as well as item information, participants with poor prefrontal functioning were able to perform as well as unimpaired counterparts on a source memory task, whereas their performance was significantly worse without these explicit instructions. This suggests that explicit instructions can be a strategy to compensate for failed spontaneous integration of item and source information at encoding. It is not currently common practice that patients are explicitly instructed to attend to the source of health information, but strategies to ensure that they attend to the source (e.g., being told to do) or compensate for the expected source memory failure (e.g., print out information so that the source is recorded, or keep a notebook of health recommendations that notes their sources) may be important for those at risk for poor source memory.

Given this background, we assessed source memory for health information in a sample of PWH and a HIV− comparison group. Participants were randomly assigned to one of two experimental “Source Instruction” conditions: a “Control” condition in which the instructions made no reference to source information, and an “Attend to Source” condition in which the task instructions explicitly direct the participant to attempt to remember the speaker associated with the health statements. We expected that both PWH and healthy comparisons would benefit from the Attend to Source instructions, but that the benefit would be greater among PWH (given their increased likelihood to have a source memory deficit). As such, we hypothesized that we would observe an interaction of HIV status and source instruction condition on health source memory performance, such that PWH would disproportionately benefit from the enhanced instructions. We also aimed to examine the pattern of source memory errors observed on the task in terms of whether source characteristics influenced the error rate and whether the experimental manipulation of task instructions influenced this pattern.

METHOD

Participants.

The sample included 102 participants who were assessed during ongoing NIH-funded studies at the HIV Neurobehavioral Research Program (HNRP) that were approved by the human research protections program of the University of California, San Diego. Participants were referred from local HIV clinics and the greater San Diego community, and all provided written, informed consent. Sixty-one of the participants were HIV-seropositive (HIV+) and 41 participants were in an HIV-seronegative comparison group. Enzyme-linked immunosorbent assay (ELISA) tests or MedMira Rapid Tests were used to determine HIV serostatus. Individuals were excluded if their verbal IQ scores were below 70 (based on Wechsler Test of Adult Reading, WTAR; The Psychological Corporation, 2001) or the Wide Range Achievement Test-4th Edition, WRAT-4 (Wilkinson, 2006); or if they reported histories of severe psychiatric (e.g., psychosis), medical (e.g., advanced liver disease), or neurological (e.g., stroke, serious traumatic brain injury, seizure disorders) conditions that are known to affect cognition, including current substance use disorder (as determined by the Composite International Diagnostic Interview; CIDI version 2.1; World Health Organization, 1998) or positive urine toxicology test for illicit substances on the day of testing. Although the comparison group was recruited to be roughly comparable to the HIV+ group in terms of exposure to potential confounds such as demographic characteristics and psychiatric disorders, the groups differed on sex, lifetime major depressive disorder (LT MDD), and lifetime substance use disorders (LT SUD) ($ps < .05$).

Upon being enrolled into the study, participants were randomly assigned to one of two Source Instruction conditions: Control Instructions versus Attend to Source Instructions. These conditions differed with respect to an experimental manipulation of the instructions for the source memory task (described in detail below). None of the demographic, psychiatric, or cognitive variables (listed in Table 1) differed by Source Instruction condition, nor did proportion of HIV+ individuals in each condition (all ps > .05). Table 1 shows these characteristics across the four groups (HIV status [HIV+; HIV−] by Instruction Condition [Control vs. Attend to Source]; all significant differences are across HIV status rather than condition).

Materials and Procedure.

All participants completed a battery including the following: an experimental task assessing source memory for health-related information, the NIH Toolbox Cognition Module, and health literacy measures as described below.

Health-Related Source Memory—This task was developed to assess item-related memory for health information, as well as source memory for those items. Participants are presented a hypothetical scenario in which they have recently been diagnosed with a fictional disease called Nephritis K Virus (NKV) infection. Participants are instructed that they need to learn the symptoms, risk factors, treatment options, and complications of NKV. Although this task utilized a fictitious disease, the type, format, and amount of information was mirrored to what would be widely available for a lay audience (using the example of a fact sheet on HCV infection on the website maintained by the National Institutes of Health, MedlinePlus (https://medlineplus.gov/). The benefit of using a fictitious disease is that there is no possibility that any participants will have had prior exposure to information about the disease. Sixteen statements about NKV appeared sequentially on a computer screen (timed, automated presentation for 15 seconds per statement to account for various reading paces, as determined by pilot testing the maximum amount of time it took to read the statements). There were 4 items/statements per each of the 4 type of information about NKV that participants were asked to learn (i.e., transmission, symptoms/prognosis, risk factors/comorbidity, treatment/side effects), presented in random order within content category blocks. Each statement was paired one of 4 possible speakers in two speaker categories: health professionals, including "Doctor" and "Pharmacist", and lay-people, including "Friend" and "Neighbor." The "speaker" was indicated by a photograph and a text label identifying the person (e.g., "Doctor says…" appeared above the photograph). The photos were selected from a bank of freely available stock photos. Both of the health professionals appeared with lab coats and were presented in context with medical content (e.g., stethoscope, pharmacy shelves), whereas the lay-person photos showed casually-dressed individuals in context with non-medical content (e.g., coffeeshop, reading a book). The speakers were all white European-American adults between the approximate ages of 25 to 35, counterbalanced on gender (two photos were women, two were men). Speaker gender was balanced across speaker category (one man and one woman in the health-professional category, and same for the lay-person category). Speaker assignment to the NKV statements was counterbalanced. Each of the four speakers was associated with four statements, one from each content category. The readability of the statements did not differ by speaker category (health professionals versus lay-people) according to multiple Flesch Kincaid indices (online calculator: https://www.webfx.com/tools/read-able/), including Flesch Kincaid Reading Ease Score (*Health Professional*: M=55.9, SD=15 vs *Lay-Person*: M=59.7, SD=13.3), Flesch Kincaid Grade Level (*Health Professional*: M=9.3, SD=2.1 vs *Lay-Person*: M=8.3, SD=1.6), Average Grade Level (equates to US schools grade level system, *Health Professional*: M=10.9, SD=2.7 vs *Lay-Person*: M=10, SD=1.7), number of words (*Health Professional*: M=16, SD=3.9 vs *Lay-Person*: M=13.5, SD=2.9), and average syllables per word (*Health Professional*: M=1.6, SD=0.2 vs *Lay-Person*: M=1.6, SD=0.2), all ps > .05. There were also no differences across the four speakers on all indices.

All participants were told that statements about NKV would be presented on the screen and that the slides would advance automatically. All participants were told to "pay close attention and read each statement carefully." For the Control condition, participants were told to "try to remember as much information as possible because you will be asked to recall this information later." In the Attend to Source Condition, the instructions were augmented as follows: "Try to remember as much information as possible, *including the person who is giving you the information*, because you will be asked to recall this information later." This augmented instruction was designed to direct participants' attention toward the source information to enhance encoding. Participants were then shown the slides containing the 16 NKV statements paired with the presenters.

Following a 5–10 minute delay, a 32-item recognition trial with 16 targets and 16 foils (4 foils per information category) was administered, in which the participant was instructed to indicate whether each item was previously seen (yes/no). Correct responses each yielded one point, and these points were summed to calculate the total number correct score, or Item Total (maximum score = 32). For each statement, participants were also asked to identify "who said it?" from a list of the four speakers (including N/A). Each correct response yielded one point. To calculate an item-corrected source memory score, the source points were summed for only those statements that had an item point (i.e., a correct response for item-level information, maximum score = 16 because N/A responses for foil items were not included). Given that the maximum score would therefore differ across participants, we created a mean item-corrected source memory score, and converted it to a z-score for ease of interpretation. Errors were coded according to whether they were semantically-related or semantically-unrelated. Specifically, a semantically-related attribution error was coded when the participant identified the incorrect source of the item information, and the chosen response was within the correct speaker category; for example, if the person named the doctor but the correct source was the pharmacist. A semantically-unrelated attribution error was coded when the incorrect source response was from the wrong speaker category; for example, if the person named the friend but the correct source was the doctor. Totals were calculated for each error type. In addition, two subtotals were calculated based on the speaker category. That is, the number of semantically-related and semantically-unrelated errors that were made for the Health Professional items were tallied separately from the Lay-Person items to determine whether there is a bias in misattribution due to source type. For clarity regarding their meaning, these errors were labeled the following: Misattribution to Another Lay-Person (i.e., semantically-related error on the lay-person subscale), Misattribution to Another Health Professional (i.e., semantically-related error on the health professional subscale), Misattribution to a Health Professional (i.e., semantically-unrelated error on the lay-person subscale), and Misattribution to a Lay-Person (i.e., semantically-unrelated error on the health professional subscale).

NIH Toolbox Cognition—The NIH Toolbox Cognition Battery, or NIHTB-CB (Gershon et al., 2013), was used to characterize neurocognitive performance. There are two tests of "crystallized cognition" that are less sensitive to acquired brain dysfunction and reflect past learning experiences (Oral Reading Recognition and Picture Vocabulary). There are five tests of "fluid cognition" assessing multiple cognitive domains that are vulnerable to acquired brain dysfunction (i.e., Picture Sequence Memory Task = episodic memory, Dimensional Change Card Sort Task = executive function/flexibility, Pattern Comparison Task = processing speed, Flanker Inhibitory Control and Attention Task = executive function/inhibitory control, and List Sorting Task = working memory). Given that the health-related source memory task that was the primary outcome in this study does not have normative standards, we used the uncorrected, census-weighted scaled scores in our analyses. These tests are combined into a Total Cognition composite score, which was used in the analyses for this study.

Health Literacy—The Rapid Estimate of Adult Literacy in Medicine, or REALM (Davis et al., 1993) is a word recognition screening tool for measuring an individual's fundamental competency to recognize and read common medical terminology related to anatomy or illnesses (e.g., anemia, antibiotics). It is scored on a scale ranging from 0 (no words pronounced correctly) to 66 (all words pronounced correctly), with higher scores indicating better literacy.

The Brief Health Literacy Screen, or BHLS (Chew, Bradley, & Boyko, 2004) is a screening tool designed to assess an individual's perceived ability to perform health-related tasks. Specifically, the BHLS consists of three questions: (1) "How often do you have someone [like a family member, friend, hospital/clinic worker or caregiver] help you read hospital materials?"; (2) "How often do you have problems learning about your medical condition because you have difficulty understanding written information?"; and (3) "How confident are you filling out forms by yourself?". For each question, individuals rate themselves on a scale of 0 to 4, and their scores are summed (range 0 to 12), with higher scores indicating a need for more assistance with their health information.

The Newest Vital Sign, or NVS (Weiss et al., 2005) consists of six questions designed to assess an individual's critical competency to read, interpret, and act on information contained on a nutrition label for ice cream. It assesses both literacy (e.g., "Pretend that you are allergic to the following substances: Penicillin, peanuts, latex gloves, and bee stings. Is it safe for you to eat this ice cream?") and numeracy (e.g., "If you eat 2500 calories in a day, what percentage of your daily value of calories will you be eating if you eat one serving?"). The total number of correct responses was used as the outcome variable for analyses (range=0–6).

Statistical Analysis.

Statistical analyses were performed using JMP Pro 14. Descriptive characteristics of the sample were examined with ANOVAs or chi-square tests, as appropriate. A multivariable linear regression was run to evaluate the association between Source Instruction condition, HIV status, and their interaction. As shown in Table 1, the study groups were largely comparable, with the exception of sex, LT MDD, and LT SUD. These differences were driven by the larger proportion of men and individuals with psychiatric and substance use comorbidities in the HIV+ groups. Although sex, LT MDD, and LT SUD differed between the groups, none of these variables was associated with the primary outcome (i.e., item-corrected source mean) and therefore they were not included as covariates. Given that broader cognitive status could influence the outcome, it was decided a priori that a measure of cognition would be included as a covariate. The Crystallized and Fluid Cognition composites from the NIH Toolbox Cognition module did not differ by group status (*p*s > .05), and each was associated with the primary outcome ($r = 0.396$, $p < .0001$ and $r = 0.488$, $p < .0001$, respectively). The Crystallized Cognition composite was selected as a covariate in the model to account for potential effects of premorbid cognitive functioning. Additionally, the Fluid Composite includes a memory measure, and the dependent measure in our study was a measure as memory as well, and therefore inclusion of the Fluid Composite as a covariate may obscure our findings. For this analysis, effect tests were reported for all independent variables and the interaction (represented by F-ratios and p-values) and the main effects of HIV status and Source Instructions Condition were examined at each level of the other factor using Indicator Function Parameterization (represented by t-ratios, unstandardized betas, and p-values). Given that our hypotheses were developed a priori based on theory and extant literature in cognitive and clinical neuropsychology, we applied a standard critical alpha level of < .05 to this primary analysis. To examine the pattern of source memory errors that were made by condition, repeated measures MANOVAs were run with Source Instruction condition and crystallized composite as between-subjects variables, and error type as the within-subjects factors. Pearson's (r) or Spearman's rho (r_S) correlations were used to examine univariable associations; i.e., to probe interactions and to examine correlates depending on the distribution of the data (with an interpretive emphasis on the magnitude of the correlation as an effect size). The following correlates of item-corrected source mean were examined: individual Fluid Cognition measures from the NIH Toolbox Cognition module (in both Source Instructions conditions separately, to explore possible differential influence of underlying cognition on the outcome between the groups), HIV disease characteristics (in the HIV+ group) and health literacy measures (in the Control group only since this was an exploration of the health relevance of our task without the prompt to attend to source, given that this is more typical of the real world, and because we did not anticipate that health literacy would influence how participants respond to the enhanced instructions in the same way that attention, working memory, or other cognitive domains would do). The outcomes are robust in terms of the requirements of regression and MANOVA; e.g., normal distribution of residuals for item-corrected source mean (Shapiro-Wilk W Goodness of Fit Test, $W = 0.99$, $p = .50$). For all secondary, pairwise, and post hoc analyses a more conservative critical alpha of < .01 was used to account for multiple comparisons.

RESULTS

For the primary analysis predicting item-corrected source memory, the overall model explained approximately 17% of the variance in item-corrected source memory. There was a significant effect of source instruction condition ($p = .046$, partial $\eta^2 = 0.040$, small-to-medium effect), such that individuals in the Attend to Source Instructions condition performed significantly better than those in the Control Instructions condition (also shown by the medium effect size reflecting better performance in the Attend to Source Instructions group show in Table 3). There was no main effect of HIV status ($p = .690$), but the effect of Source Instruction condition in the HIV+ group was at trend-level ($p = .055$). Nevertheless, due to the absence of an interaction, all subsequent analyses are collapsed across HIV status. Average level of performance and effect size differences between the Source Instructions groups on the key Health-Related Source Memory variables are shown by condition in Table 3.

We next examined the cognitive and medical variables that may be associated with the primary outcome, item-corrected source mean (see Table 4). In the Control condition, only the episodic memory measure, Picture Sequence Memory (p = .005), and the working memory measure, List Sorting (p = .0008), were significantly positively associated with item-corrected source memory (critical alpha < .01). In the Source condition, better performance on Attention and Executive Function, Flanker (p = .003), List Sorting (p = .0002), and the Executive Function measure, Dimensional Change Card Sort (p = .003) were significantly associated with higher scores on item-corrected source memory.

Next, we examined whether the source instruction condition affected the frequency of attribution error types, namely totals of semantically-related errors versus semantically-unrelated attribution errors. Given that multiple cognitive domains were observed to be associated with item-corrected source memory, we utilized the Total Cognition score from the NIH Toolbox as a covariate in these analyses. In a repeated measures MANOVA, the interaction of source instruction condition by error type was not significant ($p = .04$, critical alpha < .01; see Table 5 panel A), but the effect size comparisons in Table 3 do suggest that those in the Control Instructions condition made more semantically-unrelated attribution errors than those in the Attend to Source Instructions condition (*Cohen's d* = −0.53), whereas no differences were observed for semantically-related errors by condition (*Cohen's d* = −0.06). The three-way interaction between source instruction condition, error type, and total cognition also was non-significant ($p = .04$). Main effects of Source Instructions condition and error type were significant (ps < .01). Semantically-related and semantically-unrelated attribution errors were not correlated with each other in the Control Instructions condition ($rs = 0.03$, $p = .86$) or in the Attend to source instructions condition ($rs = 0.12$, $p = .40$).

We then examined whether there were differences in semantically-unrelated attribution errors between the two source subscales, lay-person versus health-professional, by condition (see Table 5, panel B). The outcomes in this repeated measures MANOVA were Misattribution to Health-Professionals (i.e., semantically-unrelated errors on the lay-person subscale) and Misattribution to Lay-Persons (i.e., semantically-unrelated errors on the health professional subscale). This finding is illustrated in Figure 1. We did not observe an interaction of error type by source instructions condition ($p = .14$), but there was a three-way interaction with the total cognition composite ($p = .0002$).

To probe this interaction, we stratified by source instruction condition and examined correlations between the two types of semantically-unrelated errors and the total cognition composite. These correlations revealed that in the Control Instructions condition, Misattribution to a Health Professional errors (meaning that the source was erroneously attributed to a health-professional when the correct source was a lay-person) were significantly correlated with total cognition (i.e., large effect size), whereas the Misattribution to a Lay-Person errors (meaning that the source was erroneously attributed to a lay-person when the correct answer was a health professional) were not. The same pattern was observed in the Attend to Source Instructions condition, but the correlation between health-professional semantically-unrelated errors and total cognition was weaker than in the Control Instructions condition (but this difference was only at trend-level, $z = 1.2$, $p = .11$). Moreover, semantically-unrelated errors on the two source subscales were correlated with each other in the Attend to Source Instructions condition ($rs = 0.30$, $p = .03$), whereas they were not in the Control Instructions condition ($rs = −0.08$, $p = .58$), which was a statistically significant difference (z = 1.9, p = .03).

Finally, we examined whether item-corrected source mean was associated with indices of health literacy in the Control Instructions group only. The item-corrected source mean was correlated with both of the performance-based health literacy measures, namely the NVS (r_s

= 0.31, $p = .03$) and the REALM ($r_s = 0.32$, $p = .03$), but not the self-report health literacy measure (i.e., BLHS $r_s = -0.21$, $p = .16$).

DISCUSSION

The present study aimed to evaluate source memory for health information across HIV status, expecting that enhanced instructions to attend to the source of health information would disproportionately benefit PWH, given prior evidence for an HIV-related source memory deficit (Babicz et al., 2019; Morgan et al., 2009). Our findings revealed that people with and without HIV disease are at greater risk for making source memory errors while learning health information when they are not explicitly instructed to attend to the source that information. Specifically, there is a greater risk of misattributing health information from a lay-person source as having come from a health-professional (i.e., Misattribution to a Health Professional error), as evidenced by a large effect size for this type of error versus a small effect size for the reverse type of error, which is misattributing health information to a lay-person when the correct source was a health professional (i.e., Misattribution to a Lay-Person error). This could be potentially problematic and dangerous given that people currently seek health information from a wide range of sources that vary considerably in their accuracy and credentials. Vulnerable patients, including older adults and individuals with low health literacy, have been shown to have difficulty recalling just the content of medical information and recommendations (McCarthy et al., 2014), let alone recalling multiple sources of various pieces of health information. If unreliable or unproven health recommendations are erroneously recalled as having been prescribed by a health provider, a person may be more likely to incorporate them into their health regimen, which may have significant downstream health consequences such as drug interactions, side effects, inefficacy, and so on. Our findings also suggest that the risk of health-related source memory failures may be greater among persons with poorer cognitive functioning and lower levels of health literacy.

Our findings are largely consistent with the broad source memory literature (e.g., (Glisky et al., 2001), and expand the base of evidence to source memory for complex health information. Several factors may contribute to how easily and accurately the source of information is recalled. These are summarized in a framework including: a) the characteristics of the particular episodic memory (type and amount of the perceptual, contextual, affective, semantic, and cognitive detail), b) the distinctiveness of these characteristics from source to source, and c) the efficacy of the decision process used to evaluate the plausibility and consistency of the source [see (Mitchell & Johnson, 2009) for review]. With regard to the characteristics of the episodic memory, both the item and source stimuli for the current task were designed to be relevant to recall of health information. Our task utilized a fictitious disease and the type, format, and amount of information was mirrored to what would be widely available for a lay audience (e.g., MedlinePlus (https://medlineplus.gov/). As such, there was no possibility that participants may have had prior knowledge or experience with the health information being provided. Furthermore, the finding that source memory performance was significantly higher in the Attend to Source Instructions condition compared to Control Instructions condition is consistent with those of Glisky and colleagues (2001), whose manipulation of a source memory task to explicitly direct participants' attention to source information normalized the performance of patients with frontal systems dysfunction to that of unimpaired controls. The success of our manipulation of the task instructions in improving source memory performance contrasts with the study by McDaniel and colleagues (2014) in which health-related source memory did not improve following non-specific cognitive (i.e., attentional control, prospective memory, and recollection training) and/or aerobic intervention. This suggests that training at-risk persons to use a simple yet focused reminder to attend to source information at encoding may be a better strategy for addressing a source memory deficit than indirect approaches (e.g., non-source memory trainings, exercise).

Importantly, we note that cognitive variations within the Source Instructions conditions may have influenced our findings. On one hand, we do not know to what extent participants in the Control Instructions condition attended to the source stimuli even without being prompted to do so, which would have enhanced our ability to attribute the observed findings to the source instructions manipulation. It is also possible that some individuals in the Attend to Source Instructions condition were not fully able to utilize the benefit of the instructions due to cognitive impairment (e.g., poor attention). However, we also note that the groups were comparable in terms of cognitive performance, in terms of both summary composite measures and individual measures representing domains ($ps > .05$, Table 1). Also, the different pattern of cognitive correlates in the Source Instruction conditions groups may be informative. Specifically, in the Control Instructions condition, poorer item-related source memory performance was associated with worse episodic memory and working memory (see Table 4). In the Attend to Source Instructions condition, poor item-related source memory performance was associated with worse attention, executive functioning, and working memory. This may suggest that when instructions made the goal of pairing the source with the novel health-related information explicit, the inability to do so successful was likely due to the attentional and higher-level executive functions that facilitate that pairing.

With regard to the aspect of the source memory framework addressing distinctiveness of characteristics from source to source, the error pattern in our study is somewhat different from what has been observed in other paradigms that investigated effects of semantic-relatedness. Prior experiments have shown that increasing the similarity of two speakers or the similarity of their statements increases source errors, and simultaneously increasing both forms of similarity makes correct source attribution particularly difficult (Lindsay, Johnson, & Kwon, 1991). In contrast, the pattern of errors observed here was that semantically-unrelated errors were greater in the control condition, rather than semantically-related errors. This means that participants were more likely to misattribute the source to a different category, lay-person versus health-professional, rather than to the wrong source within the same category. This relationship was most pronounced on the subscale of items for which the correct answer was one of the two lay-persons, which are labeled Misattribution to a Health Professional, suggesting that the participants tended to misattribute the health information to health-professionals even when the correct source was a lay-person. Figure 1 illustrates that the Misattribution to a Health Professional error type appears to be driving the higher semantically-unrelated error rate overall, as well. This finding speaks to the efficacy of the decision process used to evaluate the plausibility and consistency of the source. Our findings suggest that people may have a tendency or bias to attribute health information to a health-professional.

Notably, the observation of greater Misattribution to a Health Professional errors relative to Misattribution to a Lay-Person errors was observed in the context of a three-way interaction with global cognition. Specifically, greater Misattribution to a Health Professional errors were significantly related to lower cognition whereas Misattribution to a Lay-Person errors were not (as shown in Table 6). This suggests that when no external reminder to attend to the source of the health information is provided, individuals with poorer cognition are at greater risk for misattributing lay-sourced health information to a health-professional. In the Attend to Source Instructions condition, there were weaker correlations (i.e., medium effect size) between cognition and both semantically-unrelated and semantically-related errors. Perhaps when the enhanced instructions to attend to source information are given, those with lower cognitive functioning still make some errors, but those errors are made more sporadically across the task (i.e., not biased toward semantically-unrelated errors). Although there was still a correlation between Misattribution to a Health-Professional errors and total cognition in the enhanced source instructions condition, the correlation was significantly weaker than in the Control Instructions condition. This suggests that the Attend to Source instructions directing participants' attention to source information corrected for this deficit to a large degree, similar to the finding by Glisky and colleagues (2001).

While the effect of the enhanced source instructions did not differ by HIV, contrary to our expectations, this result highlights the possibility that the risk for misattribution of health information to health providers may be a broader issue that is relevant to both clinical and non-clinical populations. The hypothesized interaction of HIV status by Source Instruction condition was based on the literature showing greater source memory difficulty in PWH compared to HIV-seronegative comparison groups, which has been tied to frontal systems dysfunction (Babicz et al., 2019; Morgan et al., 2009). Though our sample size was adequate, the individual cells were nevertheless relatively small and may have precluded observation of the effects. Prior research suggests that the largest effects of HIV on episodic memory are evident in patients with HAND (Babicz et al., 2019), and in the present sample only 11% of the HIV+ individuals were impaired on the fluid composite of the NIH Toolbox Cognition module. A post-hoc examination of the item-corrected source mean variable showed a significant omnibus difference between PWH with cognitive impairment ($M = -0.66$, $SD = 0.83$), PWH without cognitive impairment ($M = 0.15$, $SD = 0.99$), and the HIV− group ($M = -0.002$, $SD = 1.0$; $p = .048$). Pairwise comparisons showed large effect sizes differences in the expected direction between PWH with cognitive impairment as compared to PWH without cognitive impairment ($d = -0.83$) and the HIV− comparison group ($d = -0.69$). This pattern of findings in post-hoc analyses suggest that PWH with HAND may be at highest risk for poor source memory performance, followed by PWH without HAND, and HIV− individuals in this sample showed the highest source memory performance. As such, despite the absence of an interaction of HIV status by condition, the performance of the study groups on this task are consistent with prior work demonstrating an effect of HAND on source memory. Demonstrating the relevance of source memory for health information in this population is particularly important given that PWH are managing a life-long medical condition with a greater proportion of medical comorbidities, and therefore are more likely to receive frequent medical recommendations from multiple sources.

Additionally, no HIV disease characteristics were significantly associated with item-corrected source memory after correction for multiple comparisons. However, the trend-level findings included worse performance in relation to nadir CD4, which is a legacy indicator of prior illness severity that has been linked to cognitive impairment previously, and CD4/CD8 ratio, which reflects current overall immune health. Such a high proportion of the sample was at or above 95% adherence to their antiretrovirals (see Table 1) that it prevented us from examining an association between adherence and performance on our task, but future work may examine this relationship and/or other indices of medical compliance, such as attendance at medical appointments.

Interestingly, source memory for health information was significantly correlated with performance-based measures of health literacy, but not self-reported health literacy. Specifically, higher item-corrected source memory scores were associated with higher scores on the REALM, a measure of oral word reading of medical terminology, and the NVS, which is a measure of the ability to apply and manipulate health information. Familiarity with medical terminology and applying health information may have made the task less overwhelming, freeing the cognitive resources to allocate sufficient attentional focus to the source stimuli to facilitate the item-source binding at encoding. This is supported by the finding that lower total cognition was associated with greater tendency to misattribute health information to health-professional sources (i.e., health-professional semantically-unrelated errors). Interestingly, there was no association between source memory performance and the BHLS, which queries the participants about how often they seek help with medical information, have difficulty learning new medical information, and about their confidence with filling out forms. At worst, this suggests that people are unaware of their difficulty with recalling the source of health information and its implications. It is also possible that people have not yet encountered these problems, but the wide variety of highly accessible health information makes this a problem that many individuals are likely to face. In prior studies, low health literacy was identified as a risk factor for several suboptimal health outcomes across multiple chronic diseases, including more hospitalizations, less engagement with preventative medicine, medication non-adherence, and higher mortality rates (Berkman et al., 2011). Poor memory for the source of health information may exacerbate these negative outcomes.

This study had some limitations that point to future directions. As mentioned above, the sample size was relatively small and may have prevented us from observed effects related to HIV or HAND. In addition, we did not include a traditional measure of source memory performance to demonstrate convergent validity with the novel health source memory task. We also did not include performance-based or real-world assessment of medical functioning, and their association with source memory for health information would be interesting to examine in future work. Our study did not include measures of medical functioning outcomes such as adherence to a medical regimen (e.g., following doctor’s medical advice, checking with a physician or pharmacist before adding a supplement, changing diet, or other types of health advice that may be found through unofficial sources), or negative medical events (e.g., side effects, medication interactions, hospitalizations). In our task design, we chose to limit speakers to a single racial group so as not to introduce the influence of race on our findings, but this would be an important and interesting question to explore in future work. Specifically, it would be beneficial to understand whether the race of the health professional influences source memory for health information, particularly for non-white patients. Moreover, it would be beneficial to understand whether mistrust of health professionals by groups traditionally marginalized by health institutions and/or people who have had negative/invalidating experiences with health professionals impacts source memory for health information. Additionally, the source element of the task may have been less relevant to non-white participants who may have found the white speakers to be non-representative of the health professionals and friends/neighbors in their day-to-day life.

It is also important to acknowledge that as with any laboratory measure of real-world functioning, our task lacks many aspects of the situation demands in real life. On one hand, a medical appointment in which a new diagnosis would be discussed is a more dynamic and complex environment than viewing a computer screen in a laboratory, and as such there is an inherent limitation in our ability to infer how performance on our tasks matches what would be observed in the real world. Future work could capitalize on the content but in a more naturalistic context, possibly using novel technologies such as virtual reality. Also, being diagnosed with a new disease would likely trigger negative emotional experiences, such as fear and anxiety, that could interfere with attention, executive functioning, and memory (including source memory) in the real world. Furthermore, individual or personal responses to certain stimuli, such as someone getting very upset about the prospect of nausea as a side effect or long-term consequences of disease, might influence their ability to attend to and encode the various features of novel health information, either by sharpening their focus on the information due to its particular salience for them. Our scenario, being a faux condition, did not elicit these emotional responses, and this is an interesting consideration for inclusion in future studies.

Although the clinical *relevance* of these findings is evident, their clinical *utility* is yet fully defined. Overall, there is limited evidence to suggest that source memory is associated with global everyday functioning in medical populations, such as HIV (Babicz et al., 2019) and aging (Schmitter-Edgecombe, Woo, & Greeley, 2009). If patients do not recall the source of medical advice correctly, it could interfere with shared medical decision-making. Specifically, if a patient erroneously believes a physician recommended a health behavior (e.g., supplement, diet) then a patient may be less inclined to discuss its potential dangers and benefits with their provider, instead trusting that it must be safe if it was recommended by a doctor. In practice, the after-visit summary sheet that is provided to all patients could be enhanced to include greater detail about the health conditions and their recommended treatments so that the patient can refer back to it as a reliable source. Moreover, this summary could recommend some reliable sources of additional information about the condition of interest (e.g., websites, articles, books). Lastly, the patient could be encouraged to pay close attention to the sources of their various health recommendations and record them so that they do not have to recall them from memory later. The latter point recommending that the information sources be recorded may be particularly important given that the explicit instruction to attend to the source of health information in this experiment only resulted in a small-to-medium effect size difference between the Source Instruction Condition groups, which highlights the challenge of accurate recall of source information and suggests that compensatory strategies should be utilized. Moreover, a recent review revealed that difficulty with internet navigation skills (as measured by performance-based tasks) is significantly associated with deficits in episodic memory and executive functions (Woods, Kordovski, Tierney, & Babicz, 2019). As such, as vulnerable people increasingly search for health-related information online, challenges with internet navigation skills coupled with greater risk for source memory errors could exacerbate the problem of remembering the source of health information and appropriately evaluating its accuracy and value before incorporating it into their health regimen.

Acknowledgements

This work was supported by awards from the National Institutes of Health: R01-MH073419 award from NIMH; HIV Neurobehavioral Research Center (HNRC)* - Center award P30MH062512 from NIMH; Translational Methamphetamine AIDS Research Center (TMARC) - Center award P50DA026306 from NIDA.

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The views expressed in this article are those of the authors and do not reflect the official policy or position of the Department of the Navy, Department of Defense, nor the United States Government.

References

Babicz MA, Sheppard DP, Morgan EE, & Paul Woods S (2019). Where have I heard that before? A validity study of source memory indices from the California Verbal Learning Test - Second edition. Clin Neuropsychol, 1–20. doi:10.1080/13854046.2019.1613559

Baldo JV, Delis D, Kramer J, & Shimamura AP (2002). Memory performance on the California Verbal Learning Test-II: findings from patients with focal frontal lesions. J Int Neuropsychol Soc, 8(4), 539–546. doi:10.1017/s135561770281428x [PubMed: 12030307]

Barragan M, Hicks G, Williams MV, Franco-Paredes C, Duffus W, & del Rio C (2005). Low health literacy is associated with HIV test acceptance. J Gen Intern Med, 20(5), 422–425. doi:10.1111/j.1525-1497.2005.40128.x [PubMed: 15963165]

Berkman ND, Sheridan SL, Donahue KE, Halpern DJ, & Crotty K (2011). Low health literacy and health outcomes: an updated systematic review. Ann Intern Med, 155(2), 97–107. doi:10.7326/0003-4819-155-2-201107190-00005 [PubMed: 21768583]

Carey CL, Woods SP, Rippeth JD, Heaton RK, Grant I, & Group HIVNRC (2006). Prospective memory in HIV-1 infection. J Clin Exp Neuropsychol, 28(4), 536–548. doi:10.1080/13803390590949494 [PubMed: 16676475]

Chew LD, Bradley KA, & Boyko EJ (2004). Brief questions to identify patients with inadequate health literacy. Fam Med, 36(8), 588–594. [PubMed: 15343421]

Craik FIM, Morris LW, Morris RG, & Loewen ER (1990). Relations between source amnesia and frontal lobe functioning in older adults. Psychol Aging, 5(1), 148–151. doi:10.1037/0882-7974.5.1.148 [PubMed: 2317296]

Davis TC, Long SW, Jackson RH, Mayeaux EJ, George RB, Murphy PW, & Crouch MA (1993). Rapid estimate of adult literacy in medicine: a shortened screening instrument. Fam Med, 25(6), 391–395. [PubMed: 8349060]

Dobbins IG, Simons JS, & Schacter DL (2004). fMRI evidence for separable and lateralized prefrontal memory monitoring processes. J Cogn Neurosci, 16(6), 908–920. doi:10.1162/0898929041502751 [PubMed: 15298779]

Doyle KL, Woods SP, Morgan EE, Iudicello JE, Cameron MV, Gilbert PE, . . . Group HIVNRP (2016). Health-Related Decision-Making in HIV Disease. J Clin Psychol Med Settings, 23(2), 135–146. doi:10.1007/s10880-016-9455-x [PubMed: 26946300]

Fazeli PL, Woods SP, Gakumo CA, Mugavero MJ, & Vance DE (2019). Critical, and not functional, health literacy is associated with missed HIV clinic visits in adults and older adults living with HIV in the Deep South. AIDS Care, 1–7. doi:10.1080/09540121.2019.1622641

Gershon RC, Wagster MV, Hendrie HC, Fox NA, Cook KF, & Nowinski CJ (2013). NIH Toolbox for Assessment of Neurological and Behavioral Function. Neurology, 80, S2–S6. doi:10.1212/WNL.0b013e3182872e5f [PubMed: 23479538]

Glisky EL, Polster MR, & Routhieaux BC (1995). Double Dissociation between Item and Source Memory. Neuropsychology, 9(2), 229–235. doi:Doi 10.1037/0894-4105.9.2.229

Glisky EL, Rubin SR, & Davidson PS (2001). Source memory in older adults: an encoding or retrieval problem? J Exp Psychol Learn Mem Cogn, 27(5), 1131–1146. doi:10.1037//0278-7393.27.5.1131 [PubMed: 11550742]

Hicks G, Barragan M, Franco-Paredes C, Williams MV, & del Rio C (2006). Health literacy is a predictor of HIV/AIDS knowledge. Fam Med, 38(10), 717–723. [PubMed: 17075745]

Hinkin CH, Hardy DJ, Mason KI, Castellon SA, Lam MN, Stefaniak M, & Zolnikov B (2002). Verbal and spatial working memory performance among HIV-infected adults. J Int Neuropsychol Soc, 8(4), 532–538. doi:10.1017/s1355617702814278 [PubMed: 12030306]

Janowsky JS, Shimamura AP, & Squire LR (1989). Source memory impairment in patients with frontal lobe lesions. Neuropsychologia, 27(8), 1043–1056. doi:10.1016/0028-3932(89)90184-x [PubMed: 2797412]

Kalichman SC, Ramachandran B, & Catz S (1999). Adherence to combination antiretroviral therapies in HIV patients of low health literacy. J Gen Intern Med, 14(5), 267–273. doi:10.1046/j.1525-1497.1999.00334.x [PubMed: 10337035]

Lindsay DS, Johnson MK, & Kwon P (1991). Developmental changes in memory source monitoring. J Exp Child Psychol, 52(3), 297–318. doi:10.1016/0022-0965(91)90065-z [PubMed: 1770330]

Lundstrom BN, Ingvar M, & Petersson KM (2005). The role of precuneus and left inferior frontal cortex during source memory episodic retrieval. Neuroimage, 27(4), 824–834. doi:10.1016/j.neuroimage.2005.05.008 [PubMed: 15982902]

McCarthy DM, Cameron KA, King JP, Mullen RJ, Bailey SC, Jacobson KL, . . . Wolf MS (2014). Patient recall of health care provider counseling for opioid-acetaminophen prescriptions. Pain Med, 15(10), 1750–1756. doi:10.1111/pme.12499 [PubMed: 25039586]

McDaniel MA, Binder EF, Bugg JM, Waldum ER, Dufault C, Meyer A, . . . Kudelka C (2014). Effects of cognitive training with and without aerobic exercise on cognitively demanding everyday activities. Psychol Aging, 29(3), 717–730. doi:10.1037/a0037363 [PubMed: 25244489]

Mitchell KJ, & Johnson MK (2009). Source Monitoring 15 Years Later: What Have We Learned From fMRI About the Neural Mechanisms of Source Memory? Psychological Bulletin, 135(4), 638–677. doi:10.1037/a0015849 [PubMed: 19586165]

Morgan EE, Woods SP, Iudicello JE, Grant I, Villalobos J, & Group HIVNRP (2019). Poor Self-efficacy for Healthcare Provider Interactions Among Individuals with HIV-Associated Neurocognitive Disorders. J Clin Psychol Med Settings, 26(1), 13–24. doi:10.1007/s10880-018-9560-0 [PubMed: 29557544]

Morgan EE, Woods SP, Weber E, Dawson MS, Carey CL, Moran LM, . . . Group HIVNRC (2009). HIV-associated episodic memory impairment: evidence of a possible differential deficit in source memory for complex visual stimuli. J Neuropsychiatry Clin Neurosci, 21(2), 189–198. doi:10.1176/appi.neuropsych.21.2.189 10.1176/jnp.2009.21.2.189 [PubMed: 19622690]

Pirogovsky E, Gilbert PE, Jacobson M, Peavy G, Wetter S, Goldstein J, . . . Murphy C (2007). Impairments in source memory for olfactory and visual stimuli in preclinical and clinical stages of Huntington's disease. J Clin Exp Neuropsychol, 29(4), 395–404. doi:10.1080/13803390600726829 [PubMed: 17497563]

Schmitter-Edgecombe M, Woo E, & Greeley DR (2009). Characterizing multiple memory deficits and their relation to everyday functioning in individuals with mild cognitive impairment. Neuropsychology, 23(2), 168–177. doi:10.1037/a0014186 [PubMed: 19254090]

Slotnick SD, Moo LR, Segal JB, & Hart J Jr. (2003). Distinct prefrontal cortex activity associated with item memory and source memory for visual shapes. Brain Res Cogn Brain Res, 17(1), 75–82. doi:10.1016/s0926-6410(03)00082-x [PubMed: 12763194]

Sorensen K, Van den Broucke S, Fullam J, Doyle G, Pelikan J, Slonska Z, . . . Consortium Health Literacy Project, E. (2012). Health literacy and public health: a systematic review and integration of definitions and models. BMC Public Health, 12, 80. doi:10.1186/1471-2458-12-80 [PubMed: 22276600]

The Psychological Corporation. (2001). Wechsler Test of Adult Reading: WTAR. San Antonio, TX: The Psychological Corporation.

Waldrop-Valverde D, Jones DL, Gould F, Kumar M, & Ownby RL (2010). Neurocognition, health-related reading literacy, and numeracy in medication management for HIV infection. AIDS Patient Care STDS, 24(8), 477–484. doi:10.1089/apc.2009.0300 [PubMed: 20662594]

Weiss BD, Mays MZ, Martz W, Castro KM, DeWalt DA, Pignone MP, . . . Hale FA (2005). Quick assessment of literacy in primary care: the newest vital sign. Ann Fam Med, 3(6), 514–522. doi:10.1370/afm.405 [PubMed: 16338915]

Wilkinson GS, Roberston GJ (2006). Wide Range Achievement Test—Fourth Edition. Lutz, FL: Psychological Assessment Resources.

Woods SP, Dawson MS, Weber E, Gibson S, Grant I, Atkinson JH, & Hiv Neurobehavioral Research Center, G. (2009). Timing is everything: antiretroviral nonadherence is associated with impairment in time-based prospective memory. J Int Neuropsychol Soc, 15(1), 42–52. doi:10.1017/S1355617708090012 [PubMed: 19128527]

Woods SP, Iudicello JE, Morgan EE, Cameron MV, Doyle KL, Smith TV, . . . Group HIVNRP (2016). Health-Related Everyday Functioning in the Internet Age: HIV-Associated Neurocognitive Disorders Disrupt Online Pharmacy and Health Chart Navigation Skills. Arch Clin Neuropsychol, 31(2), 176–185. doi:10.1093/arclin/acv090 [PubMed: 26743327]

Woods SP, Kordovski VM, Tierney SM, & Babicz MA (2019). The neuropsychological aspects of performance-based Internet navigation skills: A brief review of an emerging literature. Clin Neuropsychol, 33(2), 305–326. doi:10.1080/13854046.2018.1503332 [PubMed: 30678535]

Woods SP, & Sullivan KL (2019). Lower Neurocognitive Functioning Disrupts the Effective Use of Internet-Based Health Resources in HIV Disease: The Mediating Effects of General Health Literacy Capacity. AIDS Behav, 23(3), 676–683. doi:10.1007/s10461-018-2350-8 [PubMed: 30506473]

World Health Organization. (1998). Composite International Diagnostic Interview (CIDI, version 2.1). Geneva, Switzerland: World Health Organization.

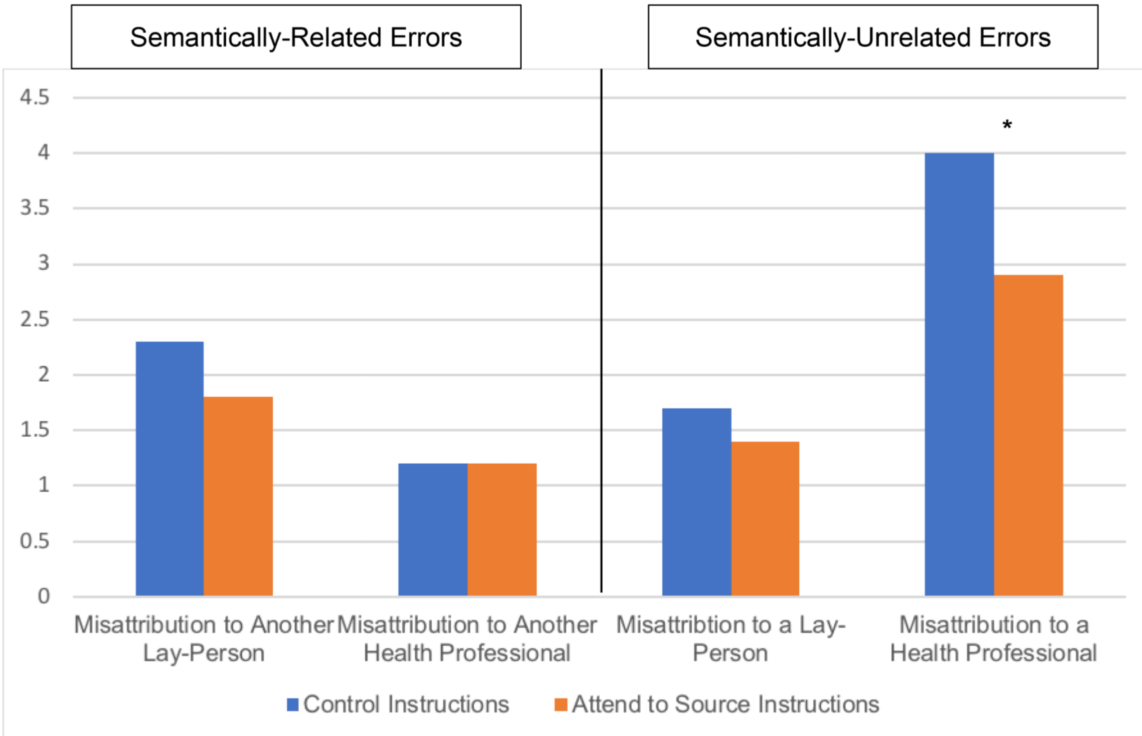

Figure 1. Bar chart showing all source memory error types by condition: Significant differences were observed for Misattribution to a Health Professional Errors only

Significantly more Misattribution to a Health Professional Errors were made by participants in the Control Instructions condition (*n* = 49) compared to the Attend to Source Instructions condition (*n* = 54), whereas no differences were observed for any other error type. This means that without being told to attend to the source of health information, participants were more likely to misattribute the source of a statement to a health-professional when the correct answer was a lay-person.

Table 1.

Descriptive characteristics of the sample

	HIV- Control Instructions (n = 20)	HIV- Attend to Source Instructions (n = 21)	HIV+ Control Instructions (n = 29)	HIV+ Attend to Source Instructions (n = 32)	*p*-value
Demographics					
Age	54 (16.7)	49.3 (18.3)	53.9 (8.3)	53.6 (9.3)	.57
Education	14.6 (2.3)	13.9 (2.4)	13.8 (2.7)	14.0 (2.8)	.76
Sex (% men)	55%	52%	86%	94%	**.0004**
Ethnicity					
% White	60%	52%	66%	53%	.06
% African American	20%	19%	21%	34%	--
% Asian	10%	5%	0	0	--
% Hispanic	5%	23%	10%	6%	--
% Other	0	0	3%	6%	
Psychiatric/Medical					
% Lifetime Major Depressive Disorder	30%	24%	59%	59%	**.01**
% Lifetime Substance Use Disorder	25%	48%	62%	59%	**.04**
% Hepatitis C Virus	10%	5%	17%	25%	.19
Estimated Duration of HIV Disease	--	--	17.0 [8.5, 25.2]	19.9 [9.4, 27.0]	.44
% Undetectable Plasma Viral Load	--	--	17%	8%	.33
Nadir CD4 Count	--	--	206 [90, 300]	210 [67.5, 354.5]	.44
% AIDS	--	--	59%	56%	.85
% On cART	--	--	75%	78%	.94
% Adherent (95%+ doses correctly taken)	--	--	93%	96%	.64
Cognitive					
NIH Toolbox Cognition					
Crystallized Composite	110.6 (10.2)	106.5 (8.0)	108.3 (8.3)	111.7 (8.4)	.15
Fluid Composite	102.1 (11.0)	102.4 (12.6)	97.1 (10.2)	100.4 (10.2)	.29
Health Literacy					
Newest Vital Sign	4.2 (1.9)	3.9 (1.7)	3.8 (1.5)	4.5 (1.7)	.37
REALM	63.4 (4.2)	64.7 (1.5)	63.5 (4.0)	65.1 (1.5)	.10
BHLS	0.4 (0.5)	0.5 (0.7)	0.5 (0.7)	0.4 (0.8)	.97

Note. CD4 = Coefficient of Differentiation 4, AIDS = Acquired Immune Deficiency Syndrome, cART = combination antiretroviral therapy, REALM = Rapid Estimate of Adult Literacy in Medicine, BHLS = Brief Health Literacy Screen

Table 2.

Multivariable linear regression results showing the association between source instruction condition and item-corrected source memory mean (critical alpha < .05)

	Adjusted R^2	*F or t ratio*	*beta*	*p*-value	*Partial eta squared*
Model: DV = Item-Corrected Source Mean	**0.165**	**F = 5.995**	**---**	**.0002**	**---**
Crystallized Cognition Composite		**F = 17.03**	**b = 0.009**	**<.0001**	**0.149**
HIV Status		F = 0.21	---	.690	0.001
Effect of HIV Status in Control Instructions Condition [HIV-]		t = −0.60	b = −0.033	.547	
Effect of HIV Status in Attend to Source Instructions [HIV-]		t = −0.05	b = −0.003	.961	
Source Instruction Condition		**F = 4.08**	---	**.046**	**0.040**
Effect of Source Instruction Condition in HIV- [Control]		t = −0.99	b = −0.059	.324	
Effect of Source Instruction Condition in HIV+ [Control]		t = −1.94	b = −0.096	.055	
HIV Status x Source Instruction Condition		F = 0.22	b = 0.036	.646	0.002

Note: For the independent variables, F ratios and their associated p-values were derived from effect tests; the effects of HIV and Experimental Condition at each level of the other factor were determined via Indicator Function Parameterization, represented by t-ratios, unstandardized betas, and their associated p-values

Table 3.

Univariable differences in performance on Health-Related Source Memory measures by source instruction condition

	Control Instructions (*n* = 49)	**Attend to Source Instructions (*n* = 53)**	***t* ratio (*P*-value)**	**Cohen's d Effect Size**
Item Total	30.1 (1.6)	29.7 (2.2)	−1.3 (.21)	−0.21
Item-corrected Source Mean (z-score)	−0.21 (0.9)	0.20 (0.13)	**2.1 (.04)**	**0.65**
Semantically−Related Errors	3.1 (1.5)	3.0 (1.7)	−0.4 (.70)	−0.06
Semantically-Unrelated Errors	5.8 (2.4)	4.5 (2.5)	**−2.8 (.007)**	**−0.53**

Table 4.

Cognitive and medical correlates of Item-Corrected Source Mean

A. Correlations with NIH Toolbox Domain Tests (critical alpha: p < .01)		
Control Condition		
Attention & Executive Function: *Flanker*	r = 0.197	p = .159
Executive Function: *Dimensional Change Card Sort*	r = 0.180	p = .216
Working Memory: *List Sorting*	**r = 0.471**	**p = .0006**
Episodic Memory: *Picture Sequence Memory*	**r = 0.394**	**p = .005**
Processing Speed: *Pattern Comparison*	r = 0.257	p = .075
Source Condition		
Attention & Executive Function: *Flanker*	**r = 0.405**	**p = .003**
Executive Function: *Dimensional Change Card Sort*	**r = 0.404**	**p = .003**
Working Memory: *List Sorting*	**r = 0.489**	**p =.0002**
Episodic Memory: *Picture Sequence Memory*	r = 0.329	p = .016
Processing Speed: *Pattern Comparison*	r = 0.277	p = .045
B. **Correlations with HIV Disease Characteristics (HIV+ only; critical alpha: p < .01)**		
Estimated Duration of Infection (years)	$r_s = -0.0007$	p = .996
Nadir CD4	$r_s = 0.292$	p = .025
Current CD4	$r_s = 0.20$	p = .144
CD4/CD8 Ratio	$r_s = 0.283$	p = .037
Plasma Viral Load (log10)	$r_s = -0.039$	p = .789

Table 5.

Repeated Measures MANOVA analyses of source memory error types: Semantically-Unrelated errors are more common than Semantically-Related errors, especially in the Control Instructions condition, and typically represent a Misattribution to a Health Professional. (Critical alpha < .01)

A. **Outcomes = Semantically-Related and Semantically-Unrelated Errors**	***F test***	***p*-value**
Between-Subjects		
Source Instruction Condition	**F (1, 99) = 0.06**	**.01**
Total Cognition	**F (1, 99) = 0.25**	**<.0001**
Within-Subjects		
Error Type	**F (1, 99) = 0.10**	**.002**
Error Type x Source Instruction Condition	F (1, 99) = 0.04	.04
Error Type x Source Instruction Condition x Total Cognition	F (1, 99) = 0.05	.04
B. **Outcomes = Misattribution to a Lay-Person and Misattribution to a Health Professional**	***F test***	***p*-value**
Between-Subjects		
Source Instruction Condition	**F (1, 99) = 0.08**	**.007**
Total Cognition	**F (1, 99) = 0.18**	**<.0001**
Within-Subjects		
Semantically-Unrelated Error type	**F (1, 99) = 0.25**	**<.0001**
Semantically-Unrelated Error type x Source Instruction Condition	F (1, 99) = 0.02	.14
Semantically-Unrelated Error Type x Source Instruction Condition x Total Cognition	**F (1, 99) = 0.15**	**.0002**

Table 6.

Correlations between Total Cognition and Source Errors: Lower cognition is associated with greater likelihood to make semantically-unrelated errors that represent misattribution of the source learned health information to health professionals (Critical alpha < .01)

Correlations with Total Cognition	**Control Instructions**		**Attend to Source Instructions**	
Semantically-Unrelated Error Types	r_s	**p-value**	r_s	**p-value**
Misattribution to a Lay-Person	−0.06	.69	−0.003	.98
Misattribution to a Health Professional	**−0.55**	**<.0001**	**−0.36**	**.008**