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Major Article

Enhancing the effectiveness of contact tracing interviews: A randomized controlled experiment of an enhanced cognitive interview protocol

Jacqueline R. Evans PhD [a,*], Haley R. Dawson BS [a], Hana Chae MA [a], Deborah Goldfarb JD, PhD [a], Ronald P. Fisher PhD [a], Rachel E. Dianiska PhD [b], Ariana Daneshbodi BS [c], Christian A. Meissner PhD [c]

[a] Florida International University, Department of Psychology, Miami, FL
[b] University of California, Irvine, Department of Psychological Science, University of California, Irvine, CA
[c] Iowa State University, Department of Psychology, Ames, IA

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Objectives: To compare the efficacy of a psychologically-based contact tracing interview protocol to a control protocol that emulated current practices under both interviewer-led and self-led modalities.
Methods: This randomized controlled experiment utilized a 2 × 2 factorial design (Enhanced Cognitive protocol vs Control protocol; Interviewer-led call vs Self-led online survey). Data were collected online (n = 200; M_{age} = 44; 56.5% female; 79.5% White) during the COVID-19 pandemic (July 2, 2020 - September 15, 2020).
Results: The Enhanced Cognitive protocol increased reported close contacts by 51% compared with the Control protocol (d = 0.44 [0.15, 0.71]). This effect was present for both interview modalities and for both identifiable and non-identifiable contacts. The Enhanced Cognitive protocol also increased both the quantity of person descriptors (d = 1.36 [0.87, 1.85]) and the utility of descriptions (r = 0.35 [0.13, 0.53]).
Conclusions: The application of cognitive principles in contact tracing interviews can significantly enhance the quantity and quality of information provided by respondents. Epidemiologists and public health investigators could benefit from utilizing cognitive principles and self-led modalities in contact tracing interviews.

BACKGROUND

Contact tracing interviews are fundamentally a memory task: Remembering all of one's close contacts over a period of time, so that they can be informed of their exposure and self-quarantine. Yet, many contact tracing training guides and protocols fail to reference memory or suggest approaches for improving recall.[1,2] They focus on *what* information to obtain (eg, names) and neglect *how to help interviewees access* that information in their memories. This is concerning, as epidemiological studies assessing recall of sexual and IV drug injection partners confirm that forgetting is common.[3] Omitted contacts and/or vague reports can be highly problematic given that these unidentified contacts may go on to spread infections in the community.

In the criminal investigation context, psychologists have applied principles of psychology to bolster recall during eyewitness interviews (eg, the Cognitive Interview).[4] Lessons from this literature apply to contact tracing. Indeed, several parallel challenges are faced during eyewitness interviews and contact tracing interviews.[5] The current research focuses on two of these challenges: omissions and vague reports. We extend earlier work[6] and examine whether interview approaches grounded in the basic memory literature can facilitate the retrieval of (identifiable) contacts. Specifically, using a randomized controlled experiment, we compared current contact training interview practices with a psychologically-informed interview protocol in the context of an ongoing COVID-19 pandemic, and tested the protocols when implemented either during an interviewer-led call or via a novel self-led online interview.

Memory retrieval

Two potential errors may occur when recalling: reporting incorrect information and omitting information. Fortunately, during free recall, incorrect details are rarely reported.[7] However, difficult memory tasks often result in omitted details, even if those details are

* Address correspondence to Jacqueline R. Evans, PhD, Florida International University, Department of Psychology, Miami, FL.
E-mail address: jacevans@fiu.edu (J.R. Evans).
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available in memory.[8] Several principles of memory retrieval are critical to overcoming omissions resulting from ineffective cuing. First, the encoding specificity principle suggests that retrieval cues are most effective when they overlap with the original episodic experience.[9] Physically reinstating context during a contact tracing interview is obviously impractical; however, reinstating context *mentally*, by thinking about the conditions of an event, can improve recall.[10] Second, providing multiple retrieval opportunities can lead to reminiscence,[11] in which participants report new, previously omitted details. For example, if you ask someone to name all 50 U.S. states, even if they know them all, they will probably forget some; but if you ask them to try again they will likely recall additional states they initially forgot. Reminiscence can be increased by varying the semantic cues provided across recall attempts.[12] For example, someone might be prompted to think of states based on region, climate, and size. Third, when selecting such semantic cues to aid interviewees' recall, cue-overload theory cautions that overly general cues (states with governors) can be ineffective.[13] Further, memory retrieval is enhanced when respondents minimize potential distractions, for example, by averting their gaze or closing their eyes.[14,15]

Self-led interviewing

Given the challenges of conducting face-to-face or telephonic contact tracing interviews,[16] we assessed whether the benefits of an Enhanced Cognitive protocol could be fully realized without the social and communicative factors introduced by an interviewer. Specifically, we tested the utility of a self-led online interview. Techniques to facilitate recall can work in the absence of an interviewer: a self-administered paper and pencil version of the well-established Cognitive Interview, known as the Self-Administered Interview, is effective for gathering recollections of an experience.[17] Self-led interviews provide a way for cases to engage in the contact recall phase of contact tracing in a way that lessens the burden on valuable human resources.

Present study

Using a randomized controlled experimental design, we compared an Enhanced Cognitive contact tracing interview protocol that applies principles of memory to a Control protocol that emulates current practices. These protocols were implemented via either (a) an interviewer-led audio-only Zoom call or (b) a self-led online survey. We hypothesized that the Enhanced Cognitive protocol would yield more reported contacts and more useful descriptions than the Control protocol, and that it would do so for both the interviewer-led and self-led modalities.

METHODS

Pre-registration, interview protocols, survey questions, data, and syntax are available on the Open Science Framework (OSF). Data collection occurred during an ongoing COVID-19 pandemic, from July 2, 2020 to September 15, 2020. All procedures were reviewed and approved by the relevant Institutional Review Boards.

Design

This randomized controlled experiment utilized a 2 (Interview Protocol: Enhanced Cognitive vs Control) X 2 (Interview Modality: interviewer-led call vs self-led online survey) between-participants factorial design. Participants were randomly assigned to conditions until approximately the final two weeks of the study, during which time random assignment was restricted to select conditions to ensure comparable cell sizes (Self-led: Control: n = 49, Enhanced: n = 50; Interviewer-led: Control: n = 50, Enhanced: n = 51).

Participants

Interested individuals signed up for the study via Amazon's Mechanical Turk, and were unaware that the study was about contact tracing; this avoided increasing the salience of their contacts and self-selection biases. Research assistants screened potential participants for eligibility during a Zoom call (see Fig 1 for details). Data from 24 participants were excluded either because they failed to appear for the scheduled interview session (n = 11) or due to experimenter error (n = 13), yielding a final sample of 200 (consistent with our pre-registered stopping rule). An *a priori* power analysis indicated that a sample of 199 provided a power of .80 to detect small-to-medium effects (d = 0.40). Effect sizes in studies testing the Cognitive Interview are typically large (eg, ds = 0.87 and 1.20, respectively, in meta-analyses).[18,19]

Participants were between 18 and 80 years of age (M = 44 years; mdn = 42; SD = 13); 56.5% of participants self-reported as female (43% male; 0.5% other). Age and gender did not differ across experimental conditions. The majority (79.5%) of the sample was White (Black/African American 8.5%; Asian/Pacific Islander 5%; all other subgroups comprised <5% each). A plurality of participants (43.5%) held a Bachelor's degree (Master's degree 19.0%; Associate's degree 13.5%; high school diploma or equivalent 9.5%; some college credit 9%; all other categories comprised < 5% each). The final sample included participants in 39 U.S. states and the District of Colombia. Participants were located in all U.S. regions, with 15.5% (n = 31) in the Northeast, 20.5% (n = 41) in the Midwest, 24.5% (n = 49) in the West, and the remaining 39.5% (n = 79) in the South. These figures align with the 2019 figures from the U.S. Census Bureau (17.1%, 20.8%, 23.9% and 38.3% respectively).

Interview protocols

Interview protocols are depicted in Figure 1 and full interview scripts are available on OSF.

To develop a control protocol that approximated, or was of higher quality than, current practices two authors completed different CDC recommended contact tracing interview training courses.[1,20] We also referenced existing contact tracing protocols.[21,22]

In the first section of the Control protocol, participants received basic instructions (a) about their task (report their contacts, and where they had been, during the last six days), (b) to get their calendar or phone (for use later in the interview process), and (c) to locate a quiet place for the interview. They then determined the specific six dates for which to report their contacts. The first set of interview questions addressed (a) participants' current living situation (eg, house, dorm) and (b) the names of those with whom they lived. Next, participants received a definition of a contact, that is, (a) physical contact (eg, kissing, hugging, shaking hands), (b) sharing saliva (eg, sharing food, being coughed on), or (c) being within six feet of someone for a period of 15 minutes or more. We developed our definition using CDC guidance and information provided in trainings available at the time of data collection. Participants were then asked to list everyone they had contact with over the last six days. Next, participants received two additional open-ended cues that asked them to report (a) their contacts at work or school and (b) "anyone else" they could remember. The remaining three sections involved calendar-assisted recall (ie, using their phone or calendar to prompt further recall), providing more detailed information for the contacts reported, and collecting more detailed information about locations reported.

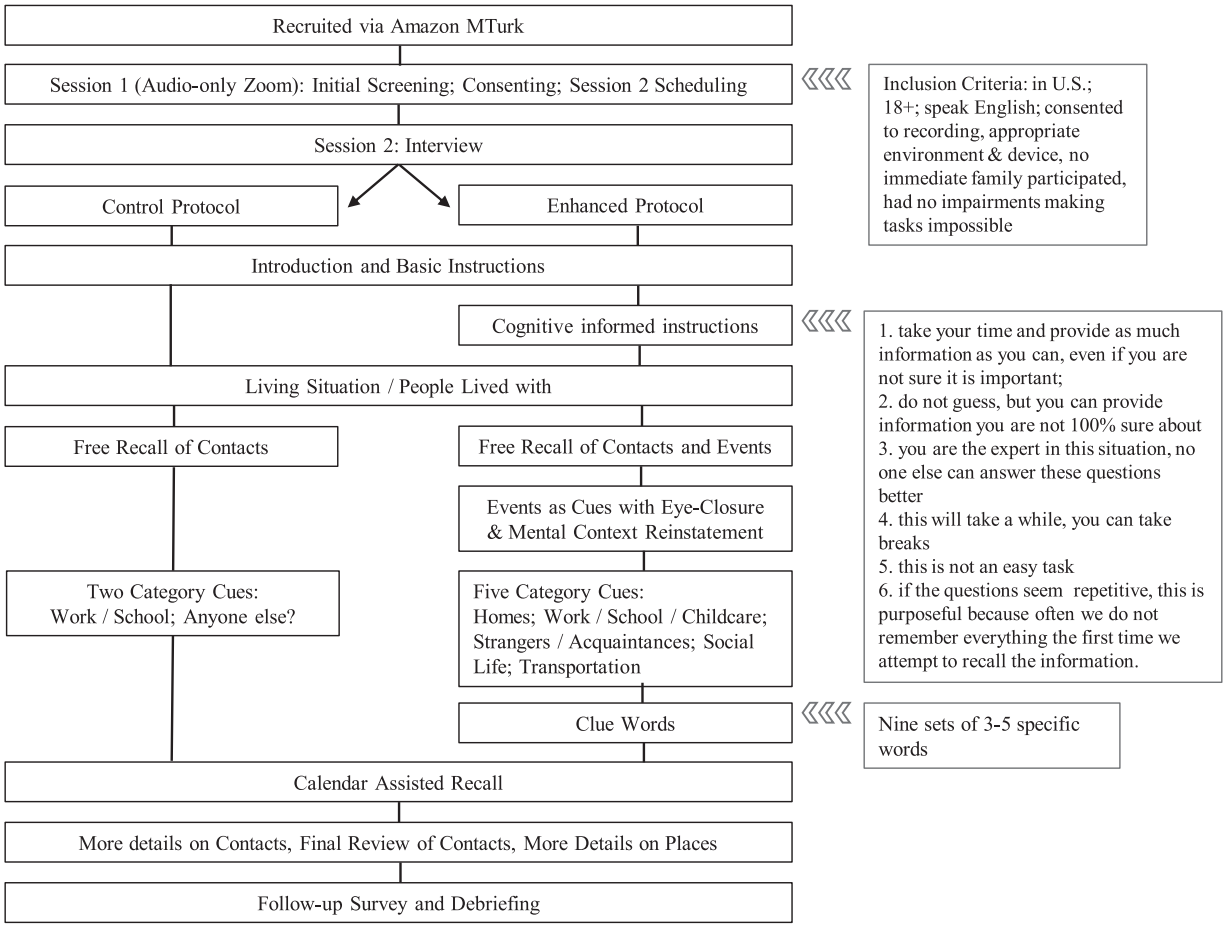

Fig 1. Detailed procedure flow.

The Enhanced Cognitive protocol differed from the Control protocol in several ways. First, participants received additional instructions designed to set appropriate expectations for the interview (see Fig 1). Next, as in the Control protocol, participants first reported their living situation and those with whom they lived and received the definition of a contact. Then, they were asked to freely recall both their contacts and the activities and events they had attended. Participants received an example list and were encouraged to describe people if they could not recall their names. After generating their lists, participants were reminded of each of the events they had listed one by one and were asked to think of any additional contacts associated with each of these events. For larger events, participants were encouraged to close their eyes and mentally place themselves back in that time and place (context reinstatement).

In the next sections, in order to prompt recall of new contacts, participants received five "category cues" followed by nine sets of more specific cues ("clues"). The category cues included: (a) homes (your home, or others' homes); (b) work/school/childcare facilities; (c) strangers and acquaintances; (d) social life (eg, celebrations); and (e) transportation (eg, ride sharing). Examples relevant to the categories were provided (eg, babysitter for homes). Next, the sets of "clues" were presented, with each set including three to five related words to prompt participants to search their memories for activities and contacts (eg, Books, Art, Outdoor, Exercise, Events). Following each set, participants reported any contacts they remembered. The final three sections were consistent with the control protocol, beginning with calendar-assisted recall.

The interviewer-led and self-led conditions were identical in content wherever possible given the constraints of the modality. In the interviewer-led condition, interviewers provided instructions and led participants through their randomly assigned protocol during a live audio-only Zoom call. Interviewers recorded participants' oral responses. In the self-led condition, participants completed the interview online via a Qualtrics survey and received the appropriate instructions from a video-recorded interviewer and via written instructions provided on-screen.

Procedure

The procedure is detailed in Figure 1. Participation took place over two sessions. At the first session, research assistants screened and consented interested individuals via an audio-only Zoom call. Participants were not informed that that they would be completing a contact tracing interview in the next session or that the session might be self-directed rather than interviewer-led. In the second session, participants completed their interview and then were directed to an online survey that included feedback responses and other miscellaneous questions regarding their experience and recent activities. Participants were then debriefed.

Coding and data analysis

To measure total contacts, each reported contact was counted, regardless of whether participants provided a full name, first name only, a label (eg, "mom"), or a person description. The number of descriptors of unnamed contacts was evaluated by coders (blind to condition) who counted the number of unique person descriptors for each unnamed contact (α = 0.95). Coders also rated the utility of the

Table 1
Mean number of recalled contacts at each interview stage across protocols

	Control			Enhanced cognitive		
	Interview stage	Mean	SD	Interview stage	Mean	SD
1	Living Situation & People Lived With	1.73	1.38	Living Situation & People Lived With	1.88	1.51
2	Episodic recall of contacts			Episodic recall of contacts and events		
	2a. Free Recall of Contacts	4.39	5.23	2a. Free Recall of Contacts & Events	4.29	4.80
	–	–	–	2b. Event Recall with Eye Closure & Mental Context Reinstatement	1.82	2.57
3	Semantic cuing of contacts			Semantic cuing of contacts		
	3a. Cued Recall: Work/School, Anyone Else	0.48	1.20	3a. Category Cues: Homes, Work/School/Childcare, Strangers/Acquaintances, Social Life, Transportation	2.01	2.98
	–	–	–	3b. Clue words	0.94	2.12
4	Calendar-Assisted Recall	1.13	2.05	Calendar-Assisted Recall	0.84	2.07
5	More details on Contacts/ Final review	0.34	1.51	More details on Contacts/ Final review	0.37	1.50
	Total Contacts	*8.01*	*6.69*	*Total Contacts*	*12.14*	*11.63*

person description via a 3-point Likert scale: *Not Useful* (a very vague description that would not be useful for locating the person), *Minimally Useful* (a description containing some unique feature that could possibly facilitate locating the person), or *Very Useful* (a very detailed description that would make identification of the person rather easy) (κ = 0.80).

For all outcome variables, Generalized Linear Models were used to assess the 2 (Interview Protocol) X 2 (Interview Modality) factorial design. Data files and analysis syntax are available on OSF, as are cell means and standard deviations for total, identifiable, and non-identifiable contacts.

RESULTS

Quantity of close contacts

Means and standard deviations of contacts reported at each interview stage are provided in Table 1. Overall, participants reported an average of 10.10 (*SD* = 9.71) [8.74, 11.44] close contacts. Participants receiving the Enhanced Cognitive protocol reported 51% more contacts (*M* = 12.14, *SD* = 11.63) than those receiving the Control protocol (*M* = 8.01, *SD* = 6.69), $W(1) = 9.53$, $P = .002$, $d = 0.44$ [0.15, 0.71]. The superiority of the Enhanced Cognitive protocol held for both the Interviewer-Led, $W(1) = 3.98$, $P = .046$, and Self-Led modalities, $W(1) = 5.72$, $P = .017$. Neither the main effect of modality, $W(1) = 0.13$, $P = .71$, $d = 0.05$ [-0.23, 0.33], nor the interaction contrast, $W(1) = .03$, $P = .87$, $d = 0.04$ [-0.24, 0.32], were significant. The additional contacts produced in the Enhanced Cognitive protocol were primarily provided during two critical interview phases unique to this protocol: On average, 1.72 additional contacts were reported when episodic recall approaches were applied, and 2.47 additional contacts were reported when semantic cueing was offered (see Table 1).

Quality of close contacts

Identifiable and non-identifiable contacts

Identifiable contacts were those for whom participants indicated that they *have* or *could obtain* contact information; other contacts were non-identifiable. The Enhanced Cognitive protocol generated significantly more identifiable, $W(1) = 4.31$, $P = .038$, $d = 0.28$ [0.01, 0.56], and non-identifiable, $W(1) = 7.59$, $P = .006$, $d = 0.40$ [0.12, 0.68], contacts than the Control protocol (see Fig 2). The number of

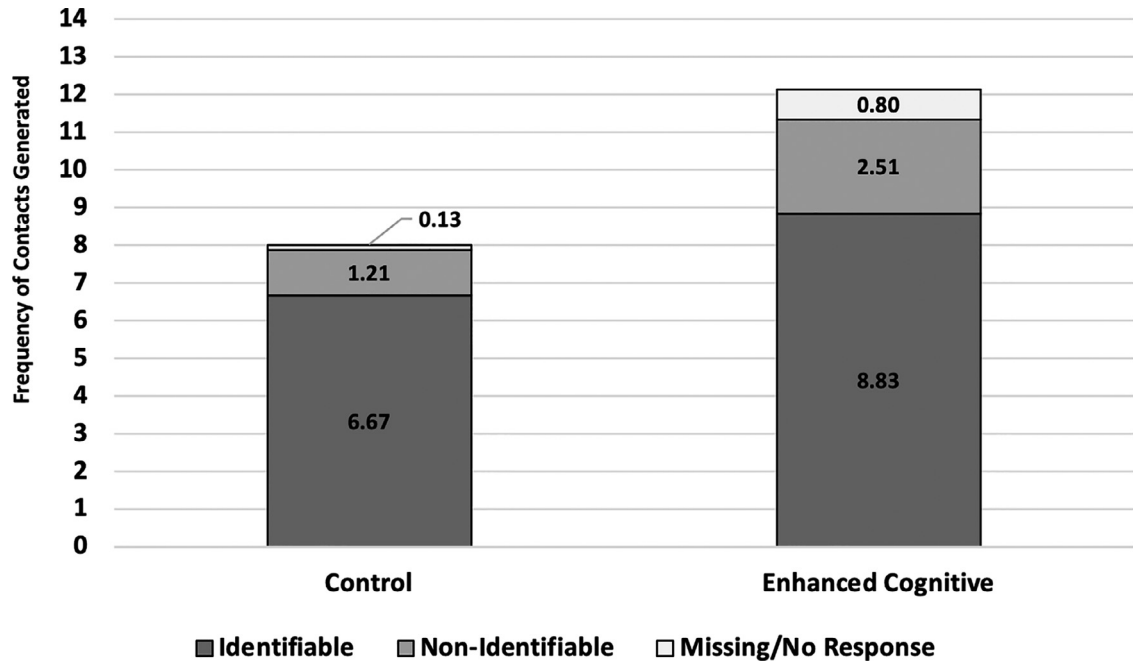

Fig 2. Average number of contacts produced across protocols representing identifiable contacts, non-identifiable contacts, or data missing/not reported.

identifiable contacts generated by the Enhanced Cognitive protocol exceeded all contacts (identifiable plus unidentifiable) generated by the Control protocol. Neither the main effect of modality, $W(1)$s <0.17, Ps ≥.68, nor the interaction contrast, $W(1)$s <1.03, Ps ≥.31, were significant.

Quantity and utility of person descriptors

A greater proportion of the contacts provided in the Enhanced Cognitive protocol consisted of descriptions than in the Control protocol, $W(1) = 5.27$, $P = .02$ (0.38 vs 0.27 respectively). Neither modality of the interview, $W(1) = 1.77$, $P = .18$, nor the interaction contrast, $W(1) = 0.002$, $P = .96$, influenced the frequency of contact descriptions.

The number of person descriptors provided per description was significantly greater in the Enhanced Cognitive protocol than the Control protocol, $W(1) = 35.93$, $P < .001$, $d = 1.36$ [0.87, 1.85], and in the Interviewer-Led modality than the Self-Led modality, $W(1) = 4.62$, $P = .03$, $d = 0.49$ [0.05, 0.94]. The interaction contrast was significant, $W(1) = 8.90$, $P = .003$, and indicated that the increase in descriptors for the Enhanced Cognitive protocol ($M = 3.56$, $SD = 1.68$ for Enhanced; $M = 1.52$, $SD = 0.68$ for Control) was greater within the Interviewer-Led modality, $W(1) = 49.37$, $P < .001$, $d = 2.28$ [1.48, 3.07], compared with the increase in descriptors in the Self-Led modality ($M = 2.39$, $SD = 1.32$ for Enhanced; $M = 1.71$, $SD = 0.77$ for Control), $W(1) = 3.83$, $P = .05$, $d = 0.64$ [0.01, 1.28].

Respondents who received the Enhanced Cognitive protocol generated descriptions that were rated as significantly more useful when compared with the Control protocol $W(1) = 9.44$, $P = .002$, $r = 0.35$ [0.13, 0.53]. Descriptions generated in the Self-Led modality were rated as more useful than those provided in the Interviewer-Led modality, $W(1) = 4.55$, $P = .033$, $r = 0.24$ [0.02, 0.44]. The interaction contrast was significant, $W(1) = 11.39$, $P < .001$, and indicated that the improved utility of descriptors in the Enhanced Cognitive Protocol was observed in the Self-Led modality, $W(1) = 37.57$, $P < .001$, $r = 0.89$ [0.69, 1.00], but not in the Interviewer-led modality $W(1) = 0.05$, $P = .83$, $r = -0.08$ [-0.42, 0.27] (see Fig 3).

Interview duration

The Enhanced Cognitive protocol took significantly longer to complete ($M = 45.47$, $SD = 26.83$) than the Control protocol ($M = 30.93$, $SD = 25.14$), $W(1) = 15.42$, $P < .001$, $d = 0.56$ [0.28, 0.84]. This roughly 50% increase in duration is not surprising given that the Enhanced Cognitive protocol uses additional retrieval attempts and yielded a 50% increase in contacts. Neither the effect of modality, $W(1) = 0.40$, $P = .53$, nor the interaction contrast, $W(1) = 0.21$, $P = .64$, were significant.

DISCUSSION

We join others in positing that an understanding of psychological science provides a path to improved contact tracing efforts.[5,23] Our results offer three consequential findings. First, an enhanced contact tracing protocol informed by cognitive psychological principles increased the number of contacts reported by 51% compared to a control protocol (roughly 12 vs 8 contacts). Second, the enhanced protocol yielded both more detailed and more helpful descriptions of unnamed contacts. The ability of the enhanced protocol to facilitate recollection of less accessible contacts appears to be the result of multiple and varied retrieval attempts that made use of both episodic and semantic memory (see Table 1). These findings are consistent with similar research in forensic investigative contexts, which consistently shows that such interview techniques can increase the quantity and quality of recollection while incurring little-to-no cost to the accuracy of reporting.[18,19] Finally, interview modality did not significantly impact the number of contacts reported (and in fact, the self-led

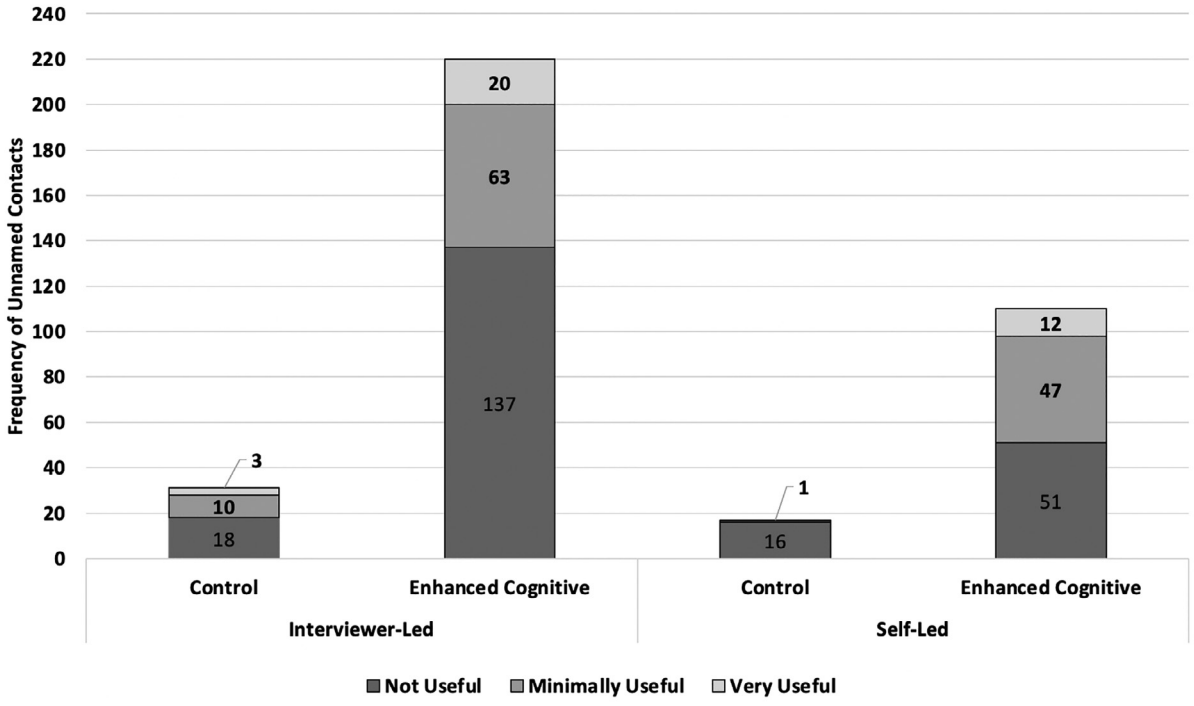

Fig 3. Frequency of descriptions scored as Not Useful, Minimally Useful, and Very Useful, across conditions.

condition was associated with more useful descriptions), suggesting that contact tracing interviews could be effectively conducted online, reducing human capital requirements.

Limitations

The current study suffers from some constraints on generality.[24] Although we recruited a national sample that provided sufficient statistical power during a relevant historical period (ongoing pandemic), our sample nevertheless was not nationally (or internationally) representative and consisted of (presumably) healthy adults. Contact tracing interviews are conducted with individuals who may be experiencing symptomology. The benefits of an enhanced cognitive protocol may be mitigated due to cognitive impairments associated with acute illness.[6,25] Conversely, a self-led interview might be particularly beneficial for symptomatic individuals, who could complete the interview at a time when they felt up to the task, at their own pace, taking breaks as needed.

We did not measure the accuracy of reported contacts; instead, we focused on the quantity and quality of reported contacts. There are three primary reasons for this. First, determining ground truth regarding every activity and interaction of a large number of people over multiple days during a pandemic would be prohibitively difficult and expensive, as well as violate the privacy of individuals who did not consent to participate. Second, the cost of forgetting a contact (a "miss") is substantial, while misremembering a contact (a "false positive"), while not without consequence, is less problematic. Third, research has found repeatedly that when asked to engage in free recall, people are generally quite accurate. Further, employing approaches like those implemented in the current study has a negligible impact on the production of incorrect responses (eg, 1%-2% change in accuracy rates).[7,18,19]

Unfortunately, our data cannot speak to whether the additional contacts reported in the enhanced condition were any more, or less, likely to become infected than contacts reported in the control condition. It is possible that memory retrieval processes are driven by some factors related to likelihood of transmission (eg, duration or frequency of contact), and it is likely the case that most high-frequency contacts (eg, household members) would be reported regardless of the interview protocol employed. That said, our participants were all instructed to report individuals who met the criteria for a "contact," and as such, all reported contacts would be at risk of infection and therefore of interest.

Finally, effective contact tracing requires that interviewees are both able and willing to participate in the process. We addressed the ability of a case to report their contacts, but not their willingness to do so – an area ripe for further research. The psychological literature provides a wealth of research devoted to improving cooperation in the investigative interview context.[26,27]

Conclusions

Pandemics, such as the current COVID-19 pandemic, require effective contact tracing to slow the spread of infection. One approach to increase the effectiveness of contact tracing efforts is to incorporate the science of memory.[5,28,29] Given a review of available training, which includes few if any mentions of memory, we cannot assume that contact tracers are aware of the limitations of human memory processes or how they relate to contact tracing. However, the current experiment demonstrates that a protocol informed by cognitive principles could provide immense benefits to contact tracing efforts. Whilst in the midst of a pandemic, training contact tracers in new, lengthier, protocols may be challenging. Fortunately, as the techniques included the enhanced approach are based in basic psychological processes, the benefits found in the current study are not unique to COVID-19. As such, the utility of psychologically-informed interview protocols would apply to other infectious diseases and can be employed more routinely in non-epidemic conditions. Once contact tracers are trained in these methods, they would be able to employ them in future epidemics without additional training, be it via a full enhanced protocol or the selective use of certain techniques (eg, eye closure and contact reinstatement instructions; cueing of general locations and activities relevant to the case). Of most importance, when human resources are limited a self-led online implementation may be particularly effective and efficient.

The success of the self-led online survey modality has important implications for approaches to infection control. Contact tracing efforts during the current COVID-19 pandemic have been hampered by a scarcity of contact tracers.[16] Self-led online administration of contact recall can allow investigators to focus on other efforts (eg, helping cases prepare for isolation or quarantine; reaching out to reported contacts). Online administration could increase participation in contact tracing efforts given its flexibility – it can be done at virtually any time or place (within the context of a locale with accessible internet) and at a pace that is driven entirely by the interviewee. This flexibility also permits early intervention – for example, individuals could receive a link to a self-led contact tracing survey at the time of COVID-19 testing, receipt of results, or at point of care. Potential cases could then recall their contacts days before they would otherwise attempt to do so (during a call from the health department) and while their memories are "fresh" and less subject to decay or interference. Given the reproductive number (R0) of the original COVID-19 strain has been estimated at three while the more recent Delta variant has increased to an estimated at five,[30] identifying additional close contacts, as soon as possible, could lead to substantial reductions in peak daily cases, and/or delay those peaks.[31]

In summary, our findings suggest that contact tracing efforts, both in the current pandemic and in the future, can be improved by taking an interdisciplinary approach that incorporates psychological science.

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