People consider reliability and cost when verifying their autobiographical memories

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Abstract

Because memories are not always accurate, people rely on a variety of strategies to verify whether the events that they remember really did occur. Several studies have examined which strategies people tend to use, but none to date has asked why people opt for certain strategies over others. Here we examined the extent to which people's beliefs about the reliability and the cost of different strategies would determine their strategy selection. Subjects described a childhood memory and then suggested strategies they might use to verify the accuracy of that memory. Next, they rated the reliability and cost of each strategy, and the likelihood that they might use it. Reliability and cost each predicted strategy selection, but a combination of the two ratings provided even greater predictive value. Cost was significantly more influential than reliability, which suggests that a tendency to seek and to value "cheap" information more than reliable information could underlie many real-world memory errors.

Keywords: autobiographical memory; false memory; verifying strategies; information-cost trade-off

Classification codes: **2340** Cognitive Processes, **2343** Learning & Memory

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1. Introduction

US Presidential hopeful Mitt Romney recently described memories of attending the Golden Jubilee celebrations of the automobile on June 1, 1946, with his father, the Grandmaster of Ceremonies. By his own admission, Romney's memories were "a little foggy." It's no wonder—journalists were quick to discover that the celebrations happened 9 months before he was born (Knapp, 2012). Like Romney, numerous people have discovered their memories of significant events are wrong, sometimes wildly wrong. We have also learned from research the ways that people discover their autobiographical memories are wrong, and the strategies they select to distinguish genuine events from fictitious events (Arbuthnott, Kealy, & Ylioja, 2008; Mazzoni, Scoboria, & Harvey, 2010; Wade & Garry, 2005). We know, for example, that relying on other people as well as on cognitive strategies such as imagining the event are common techniques people adopt to verify their autobiographical memories (Wade & Garry). What we do not know, however, is why people choose these strategies—especially techniques that could ultimately promote rather than prevent memory distortions. In this paper, we draw on the action-perception and decision-making literatures to help answer this question (Chu & Spires, 2003; Kool, McGuire, Rosen, & Botvinick, 2010).

1.1 Choosing Verification Strategies

We know that many people recall events they no longer believe really happened (Mazzoni et al., 2010; see also Clark, Nash, Fincham, & Mazzoni, 2012; Otgaar, Scoboria, & Smeets, 2013). Why do people suddenly stop believing in memories they have held for months or even years?

Research suggests that long-held personal memories are often rejected because the memory itself may not seem right—it may not feel very coherent, or the memory might conflict with other autobiographical knowledge, such as the recollections of others who witnessed the event (Arbuthnott et al., 2008; Conway, Collins, Gathercole, & Anderson, 1996). In one study, for instance, people stopped believing because they obtained crucial information from family members, found physical evidence proving the event never happened, or reasoned that the event was implausible (Mazzoni et al., 2010). Other research overlaps with these findings. For instance, when subjects recalled childhood memories of questionable accuracy and then described how they verified those memories, the two most popular strategies involved asking family members for information, or cognitive approaches such as concentrating on the memory and trying to recall further details (Wade & Garry, 2005). When the subjects imagined hypothetical events, the strategies they suggested were similar. Likewise, when people reported how they determined whether a memory was from a dream or the result of genuine experience, again the two most popular strategies were asking other people for information, and checking for physical evidence (Kemp & Burt, 2006). These studies converge on the idea that people tend to adopt a few preferred strategies for distinguishing fact from fiction in memory.

It makes sense that people turn to physical evidence—when it is available—to verify distant memories: physical evidence, like medical records, family photos or personal diaries, is likely to remain reliable and robust over extended periods of time. In contrast, it could be considered surprising that people frequently rely on other people's memory reports or on cognitive approaches to authenticate events. Both strategies are far from foolproof. Hundreds of studies demonstrate the fragility and malleability of human memory, so when relying on other people for information the chances of making errors could increase along with the number of informants (Schacter, 1999; Wright, Memon, Skagerberg, & Gabbert, 2009). The same is true, of course, for relying on one's own cognition as a means of gathering information about an event: false childhood memories occur when people repeatedly imagine counterfactual events and subsequently confuse imagination, thoughts and other information for real memories (M. K. Johnson, Hashtroudi, & Lindsay, 1993; Strange, Wade, & Hayne, 2008). Imagination on its own can promote distortions in autobiographical beliefs and in memories (Garry, Manning, Loftus, & Sherman, 1996; Hyman & Pentland, 1996; Mazzoni & Memon, 2003; Sharman & Scoboria, 2009).

Why do people choose to use unreliable strategies? The decision-making and action-perception literatures may help to answer this question. They show that our decisions and actions are often tuned toward maximizing gains while minimizing effort, and this approach, when applied to the selection of verification strategies, could lead us to eschew reliable strategies for unreliable ones.

1.2 The Reliability and Cost of Information

Studies on human decision processes suggest that when people seek information and have a variety of sources to choose from, they often select the source that maximizes reliability, that is the likelihood of accruing accurate and useful information, and minimizes the cost, such as the physical, cognitive, and/or financial investment required to obtain that information. This approach is called *optimizing* in the decision-making literature and is observed in many information-seeking tasks (Beach & Mitchell, 1978; Chu & Spires, 2003; E. J. Johnson & Payne, 1985). Consider the strategies you might use to select a winning racehorse. You could read the race day program, look at the horses in the field, or rely on superstitious beliefs ("Celestial Choir is wearing my lucky number!"). Each horse-picking strategy offers information to help you select a horse, but among other important characteristics each strategy differs in the reliability and in the cost of the information it provides. The race day program is crammed with useful statistics that reliably predict a winner, but the numbers and jargon may be impenetrable and demand copious amounts of time and cognitive effort to understand. Looking at the horses before they get to the track could provide valuable information about their form, but if the horses' enclosures were not readily accessible to the general public then securing this information could exact a major financial cost. Finally, using your superstitious beliefs to select a horse does not lead to a smart bet, but it is fast and requires little cognitive effort. When we make selections we prefer reliable over unreliable information, and cheap and readily-accessible over costly information, but reliability and cost are rarely independent. As our horse racing scenario shows, reliable information can come at considerable cost.

If people make cost-benefit analyses when choosing verification strategies, how might they weight the reliability and cost of different types of information? One prediction is that people will be guided by reliability. Autobiographical memories are important—they define who we are, shape our identity, and facilitate social interactions, so it makes sense to seek accurate and reliable information when verifying our memories (Demiray & Bluck, 2011; Williams, Conway, & Cohen, 2008; Wilson & Ross, 2003). We also use autobiographical memory to solve current problems and to prepare for the future: research from several domains shows that memory plays a crucial role in the mental simulation of future events (Szpunar, 2010; Szpunar, Addis, & Schacter, 2012). So it seems plausible that when it comes to verifying autobiographical events, people might adopt strategies that they believe generate reliable information—even if they thought those strategies exact substantial cost. We know that jurors find physical evidence particularly compelling. Jurors are more likely to be swayed by physical (trace) evidence such as shoeprint evidence, for instance, than by eyewitness testimony (Skolnick & Shaw, 2001; see also Ask, Rebelius, & Granhag, 2008). Research also suggests that people find neuroscience explanations persuasive, possibly because such accounts provide evidence of a link between brain activity and behavior (Gurley & Marcus, 2008; Weisberg, Keil, Goodstein, Rawson, & Gray, 2008; see also Michael, Newman, Vuorre, Cumming, & Garry, 2013 for limitations of persuasive neuroscience evidence). Together these studies suggest that people perceive physical evidence to be extremely reliable. Therefore we might expect people to prefer searching for physical evidence if reliability is an important consideration.

Another prediction is that people might consider cost to be more important than reliability when selecting verification strategies. The Principle of Least Effort argues that people's fundamental concern is to maximize gain while minimizing the amount of effort, or cost, they expend in all aspects of behaviour (Zipf, 1949; see also Kool et al., 2010). Indeed, practitioners in various industries prefer easily accessible information over high-quality information (Gerstberger & Allen, 1968; Hardy, 1982; O'Reilly, 1982). The principle often holds in commonplace activities too. People routinely climb stairs or traverse obstacles, for example, so as to maximize gain while minimizing metabolic cost (see Sparrow & Newell, 1998 for a review). Findings such as these lead us to predict that when selecting from the strategies available to them, people might prefer "cheap" and readily-accessible strategies at the expense of reliable ones. Research on transactive memory systems, whereby people cope with the cognitive burden of remembering by relying on accounts of others, suggests that subjects might perceive other people, particularly family members, as low-cost sources (Wegner, 1987). It is also likely that subjects would perceive cognitive strategies, such as thinking about the plausibility of the event, as cheap, because these strategies presumably involve no physical or financial expenditure and they rely on resources that are usually guaranteed to be available (Nash & Takarangi, 2011). If people do aim to minimize cost, such a finding would help to account for the preference among subjects in prior studies to rely both on other people and on cognitive strategies when verifying their memories.

In sum, people determine the veracity of their memories through a range of strategies, but we know little about how and why particular strategies are chosen. To address this issue, we asked adults to describe a childhood memory, and to consider how they might determine the source of that memory if someone denied that the event occurred. Adapting Wade and Garry's (2005) coding, we classified each strategy as either [1] *Family* - checking information with family members; [2] *Others* - checking information with non-family members; [3] *Cues* - searching for items or situations to improve recall, for example returning to the location of the event; [4] *Physical* - searching for physical evidence; or [5] *Cognitive* - cognitive techniques such as trying to remember more details. Subjects then rated how reliable and costly each of their named strategies might be, and how likely they might be to use them.

2. Method

2.1 Subjects

In exchange for course credit, 237 undergraduate students from the University of Washington taking an introductory psychology course volunteered for a study investigating the strategies people use to verify memories of childhood experiences.

2.2 Procedure

Subjects were given 50 minutes during class time to complete a questionnaire about the strategies people use to verify memories from long ago. Subjects were asked to describe in as much detail as possible “a childhood incident for which you needed medical, dental, a school nurse, or a teacher’s attention shortly afterward. This should be an event from your grammar-school years (primary school), one that you remember well.” Of course, different childhood events could render different verification strategies available to the subject. It is important to note that our primary interest in this study was in how people weighed up the verification strategies that were available to them, rather than in the specific strategies they suggested. We chose the childhood incident as our target event-type because these types of experiences are significant enough to be permanently documented somewhere or to leave physical proof, and they have a high likelihood of being remembered by others, such as the subjects’ parents. Thus this type of event gave subjects a variety of options for verifying the experience that would vary substantially in their reliability and cost.

Subjects were next told:

> Suppose you are telling this event to someone, and this person challenges your memory. This “challenger” says to you, “No, that never happened. You’re wrong.” At first you disagree, but then you start to wonder, “Did this really happen? Am I imagining this? Do I just remember something I saw on TV, or heard others talk

> about?" Your task is to convince yourself once and for all, whether or not the event actually happened.

Subjects were instructed to list five things that they might do to verify this memory, and what information they would be looking for from each strategy. These instructions required subjects to report only the strategies that might reasonably be available to them and that would have a good likelihood of providing information. Next they were asked to rate each of their five strategies for information reliability and cost. For reliability, subjects responded to the question: "Is the information you would get as a result of this strategy indisputable, trustworthy and accurate? (1 = not very reliable at all; to 5 = extremely reliable)." For cost, subjects responded to the question: "Does the information strategy require you to spend a great deal of money, time, energy, effort, labor, aggravation (1 = very small cost; to 5 = very high cost)? For each strategy, consider these costs as a whole; that is, TOTAL COST = money + time + energy + effort + labor + aggravation." Finally, subjects rated how likely (from 1, *extremely unlikely*; to 5, *extremely likely*) they would be to pursue each strategy given their estimates of reliability and cost, and they also selected the single strategy they would be most likely to try first. In the subsequent class session, subjects learned about the aims of the study.

3. Results and Discussion

After excluding data from 16 subjects who failed to provide likelihood ratings or follow instructions (e.g., describing a general observation instead of a childhood memory), 221 subjects remained in the dataset, each of whom provided a memory report. Those 221 memories spanned the full age range from 5 to 11 years, and were of moderately significant autobiographical events such as injuries caused by falling off a bicycle, fighting in the playground, or falling from a tree.

To determine what strategies people might use to verify their childhood memory, we asked two independent raters—psychology students who were unaware of the purpose of the study—to classify the 1105 memory verification strategies (221 subjects x 5 strategies). The raters were carefully trained in the classification process and agreed on 94% of classifications (Cohen's κ = .92). Disagreements were settled by discussion. As expected, subjects reported a wide range of strategies for verifying their reported childhood incident. Over a third of the strategies (37.5%) involved searching for physical evidence. For example, subject M reported falling off a climbing frame as a child and indicated that she would check for scarring from stitches or contact the hospital for medical records. Another subject who reported an accident during a Scout event said he would search for photographs to verify the event. More than half of the strategies involved asking another person: either a family member (27.0%) or somebody else such as a neighbor, friend, teacher or doctor (26.2%). For instance, subject K reported being sick on her 3rd grade teacher's shoes and would verify this by asking family members or contacting the teacher. Some strategies were categorized as involving cognitive techniques (3.5%) such as concentrating on the memory and attempting to recall more details. The remaining strategies involved searching for additional memory cues (5.9%), for example, returning to the scene of the event to help trigger memories.

We now turn our attention to how reliable and costly subjects perceive different verification strategies to be, and how they ultimately select a strategy to use from the strategies available to them. In the following analyses we used R® and the statistical package lme4 to conduct linear mixed effects models (*LMMs*, Bates, Maechler, & Bolker, 2013; R Core Team, 2013). Because the LMMs methodology rarely appears in the autobiographical memory literature, a brief overview is helpful. Put simply, it is an extension of the regression analytic approach, intended for modeling both fixed and random effects that contribute variability to data. Unlike ordinary regression analysis, which assumes that observations are independent, LMMs account for dependence in data, including the dependence inherent in a repeated-measures design. Put another way, the LMMs method can account for the additional sources of variance that emerge between subjects as well as variance that emerges between the levels of other grouping variables. LMMs account for different sources of variance by adding random effect parameters into the regression model, which would normally include only an intercept parameter (i.e., the point at which the best-fit line crosses the y-axis), a slope gradient parameter for each predictor variable, and an error term. In the experiment we present here, for example, we can add parameters that allow the intercept term in the ordinary regression model to vary for each subject, and indeed for each type of strategy where appropriate (termed a random intercept model). Similarly, we can add parameters that allow the slope gradient to vary for each subject or for each strategy type (termed a random slopes model). LMMs can account for and model these extra sources of variation, which ultimately enables us to achieve proper control of Type 1 error in light of the violation of the assumptions of ordinary regression.

Because the LMMs approach allows us to model these additional sources of variation between subjects, one implication is that LMMs deals well with "missing" data. In our design, although subjects reported five strategies each, each subject did not necessarily report just one Family strategy, one Others strategy, one Cue strategy, one Physical strategy, and one Cognitive strategy. Instead, subjects tended to report more than one strategy for particular categories. For instance, Subject X reported two Cognitive, two Physical, plus one Cue strategy, whereas

Subject Y reported one Cognitive, one Physical, two Family, and one Other strategy. LMMs can accommodate this type of non-independent data with missing values, and so fit the bill for our research (see Collins, Schafer, & Kam, 2001).

Before modelling our data, we standardized the predictors and outcome variables—the Reliability, Cost, and Likelihood ratings—to produce standardized regression coefficients. We report these standardized coefficients throughout because they serve as a standardized effect size statistic and show the effect of an independent variable in terms of standard deviations. We also report Markov chain Monte Carlo (MCMC) *p*-values where appropriate because they avoid the issues of counting parameters or, more generally, approximating degrees of freedom in LMMs (see Baayen, Davidson, & Bates, 2008).

(Figure 1 about here)

3.1 Reliability and Cost Ratings

Did subjects consider some verification strategies to be more or less reliable than other strategies? To address this question, we calculated the mean reliability and cost ratings for the five different types of strategies, and display the results in Figure 1. As the left panel shows, subjects found physical evidence and family evidence to be highly reliable, but physical evidence was considered more reliable than asking a family member. Both physical evidence and asking family members were also rated as being more reliable than asking other relevant people, looking for memory cues, or using cognitive techniques. This tendency for subjects see their family members' memories as nearing the reliability of physical evidence is striking, yet it fits with the notion that we often entrust our close relations as keepers of our memories through the establishment of transactive memory systems (Wegner, 1987). It is striking that none of the strategy-types were rated, on average, as being extremely low in reliability, or extremely high in cost. This finding could be an artifact of the instructions we gave to subjects and the five strategies they listed. As noted above, we asked subjects to report which strategies they might use, which most likely encouraged them to list only the strategies that they would reasonably consider using.

To examine using inferential statistics whether subjects considered some verification strategies to be more or less reliable than others, we conducted an LMM for reliability, conditional on strategy and with a random intercept for subjects. The analysis showed a significant effect of strategy, $\chi^2(4) = 238.07$, $p < .001$. To contrast each pair of strategy-types we used the regression coefficients in the reliability model and a Bonferroni-corrected $\alpha = .005$, which revealed physical evidence was greater in reliability than asking a family member ($b = -.24$, $SE = .08$, $t = 2.88$, $p = .004$) and these were both greater than other relevant people, memory cues, or cognitive techniques (largest $p = .001$ with $b = -.78$, $SE = .19$). There were no other significant differences with respect to reliability.

As the middle panel of Figure 1 shows, subjects also rated some strategies as more cost-efficient than other strategies. That is, the LMM for cost, conditional on strategy and with a random intercept for subjects, revealed a significant effect of strategy, $\chi^2(4) = 325.91$, $p < .001$. More specifically, post-hoc comparisons ($\alpha = .005$) showed that subjects rated family members' memories and cognitive techniques as very cheap, in fact, both were cheaper than the remaining three strategy types which were rated as moderately costly (largest $p < .001$ with $b = 1.82$, $SE = .27$). The costs of asking family members and using cognitive techniques were similar ($t = 0.06$, $p = .96$, $b = -.01$, $SE = .23$), and physical strategies were considered cheaper than relying on the memories of third parties ($t = 3.26$, $p < .001$, $b = -.33$, $SE = .10$). There were no other significant differences.

We then examined the perceived relationship between reliability and cost. Did reliability come at a cost? The answer is that it depended on the strategy. Our LMM showed that when subjects suggested strategies involving other people or family members, they thought they could get more reliability for less cost. This finding makes sense, because the most reliable people to ask are likely to be one's closest friends or family members, who are also the easiest to access. In contrast, when subjects suggested strategies that involved physical evidence, such as acquiring medical records or searching for childhood photos, they thought reliability would come at a cost. We return to consider these findings in more detail later.

In other words, to examine the relationship between perceived cost and reliability, we conducted a LMM with reliability as the outcome, cost as a predictor, and a random intercept and random slope for subjects. In this model which collapsed across all strategy-types, cost was a negative predictor of reliability, rather than a positive predictor, $b = -.13$, $SE = .03$, $t = 3.92$, $p < .001$. But when we added a random intercept for strategy-type into the model, we achieved a better fit, as indexed by change in -2 log likelihood, $\chi^2(1) = 214$, $p < .001$. Adding a random slope for strategy-type further improved the fit, $\chi^2(2) = 44$, $p < .001$. This result meant that the relationship between Reliability and Cost interacted significantly with strategy-type, and therefore we conducted post-hoc analyses for each strategy-type separately ($\alpha = .01$). These analyses showed the patterns reported above. The perceived cost of asking family members or other people was a negative predictor of their perceived reliability [Family, $b = -.33$, $SE = .11$, $t = 3.08$, $p = .004$; Others, $b = -.34$, $SE = .06$, $t = 5.56$, $p < .001$]. In contrast, the cost of Physical strategies was a positive predictor of their reliability, $b = .11$, $SE = .04$, $t = 2.57$, $p = .01$). The cost of Cue strategies was not a significant predictor of their reliability, $b = .17$, $SE = .15$, $t = 1.16$, $p = .26$, and nor was the cost of Cognitive strategies, $b = .08$, $SE = .20$, $t = .43$, $p = .68$.

3.2 Deciding Which Strategies to Use

Which strategies were subjects most likely to use from those they suggested? To address this question, we first examined subjects' mean likelihood ratings for each type of strategy, which appear in the right panel of Figure 1. As the figure shows, subjects reported that they would be highly likely to use family members and only moderately likely to use all of the other strategies. Given that asking family members was rated as both highly reliable and low in cost, it is perhaps unsurprising that subjects said that turning to family members would be their most likely strategy. This result fits with the prediction that people should prefer strategies that maximize reliability while minimizing costs. Subjects were also more likely to search for physical evidence or use cognitive techniques than to rely on other people's memories or to search for additional cues.

These findings were echoed via a LMM with likelihood as the outcome, conditional on strategy, and with a random intercept for subject, which revealed a significant effect of strategy, $\chi^2(4) = 241.05$, $p < .001$. Post-hoc comparisons ($\alpha = .005$) showed that subjects were more likely to rely on family members than on any other strategy type (all p's < .001, smallest $b = -1.01$, $SE = .24$). Subjects preferred physical evidence and cognitive techniques over other people's memories or searching for additional cues (largest $p = .001$, smallest $b = -.90$, $SE = .28$). There were no further significant differences.

At this point it is interesting to note that different patterns have emerged across different strategy types. For instance, subjects said they would be just as likely to use physical strategies as cognitive strategies. But they saw physical strategies as being very high in reliability and moderately high in cost, whereas they saw cognitive strategies as moderately high in reliability and very low in cost. When taken together, these data do not provide a clear picture of how subjects chose to verify their memories. To better understand the basis of subjects' decisions, we examined whether subjects considered reliability, cost, or a combination of both when determining which strategy they might use from the available set. Accordingly, we collapsed across all five strategy types and looked at how well reliability, cost, or a combination of both predicted subjects' likelihood ratings. We found that both reliability and cost played a crucial role in subjects' decisions, but ultimately, subjects relied on cost more than reliability to make their decisions.

More specifically, to answer this question we conducted three separate LMMs. The LMMs had likelihood as the outcome variable, a random intercept and a random slope for subjects, and had (1) reliability alone, (2) cost alone, and (3) reliability and cost as predictors, respectively. The analyses showed that both reliability and cost, when entered into models separately, predicted subjects' likelihood ratings (Reliability, $b = .39$, $SE = .03$, $t = 12.63$, $p < .001$; Cost, $b = -.64$, $SE = .03$, $t = 18.98$, $p < .001$). In the model that included both reliability and cost as predictors, both had significant unique effects (Reliability, $b = .31$, $SE = .03$, $t = 12.11$, $p < .001$; Cost, $b = -.61$, $SE = .03$, $t = 19.07$, $p < .001$). Together these results reinforce our conclusion that subjects took both reliability and cost into account when making likelihood ratings. But the magnitude of the regression coefficients in the latter analysis suggested that reliability was not as influential as cost. To address this possibility, we used Wilcox and Tian's (2008) D1 method to compare dependent correlations. Here, we compared the correlation between reliability and likelihood, with the correlation between cost and likelihood. According to this method, if one predictor variable—reliability or cost—has a greater contribution to predicting likelihood than does the other variable, then z(Reliability) – z(−Cost) should correlate significantly with likelihood.[1] Such a finding would tell us that the perceived cost of a strategy was a significantly better predictor of the likelihood of using that strategy than was its perceived reliability. Indeed, a new LMM showed this pattern, $b = .04$, $SE = .02$, $t = 2.42$, $p = .02$. Put simply, this finding strengthens our conclusion that subjects consider cost to be more important than reliability when selecting from available verification strategies.

Did the same pattern hold for each individual strategy? That is, would subjects value cost over reliability when deciding to use a particular type of strategy? For four out of five of the strategy types, the answer was yes. As the regression coefficients in Table 1 show, for Family strategies, Other strategies, Physical strategies, and Cue strategies, subjects were more inclined to use these strategies if they perceived them to be both cost effective and reliable, but cost still factored higher in these decisions than did reliability. The last row in Table 1 shows that Cognitive strategies were the exception. Subjects tended to use Cognitive strategies if they perceived them to be reliable, but subjects did not consider cost to be important in these decisions (although the small number of observations may be partly responsible for this finding).

In particular, to examine the role of perceived cost and perceived reliability in subjects' decisions to use each type of strategy, we adapted the LMM containing both reliability and cost as predictors of likelihood, by adding a random intercept for strategy-type. The new model produced a substantially better model fit in terms of -2 log likelihood, χ^2 (1) = 22, $p < .001$, and adding a random slope for strategy-type improved the fit further, χ^2 (2) = 8, $p = .02$. Thus the relationship of reliability and cost with likelihood interacted significantly with strategy-type. Table 1 shows the regression coefficients for reliability and cost when used together as predictors of likelihood, calculated separately for each strategy-type. Despite the interaction, across most strategy-types we saw the same general pattern: reliability and cost had significant unique predictive effects, but the predictive value of cost was generally greater in magnitude than that of reliability. These results highlight that people did not simply rule out using certain types of strategy. Rather, subjects were much more inclined to use most types of strategy when they could think of a reliable way of doing so, and especially when they could think of a cheap way.

3.3 Most-preferred strategies

Recall that we asked subjects to choose the single strategy from the five they suggested that they would most likely use first. We found that more than half of all subjects opted for asking a family member (56.1%) and approximately one-third opted for searching for physical evidence (33.0%). Interestingly, though, when we looked at subjects' ratings of these most-preferred strategies, we found that they still more often chose the strategy they had rated least costly of their five suggestions than the strategy they rated most reliable. Specifically, 82% of subjects chose the strategy they rated least costly (including matches), whereas 71% chose the strategy they rated most reliable, McNemar's exact $p = .01$ (Odds ratio = 1.78). This finding provides converging support for the conclusion that people prefer to minimize cost than to maximize reliability when verifying memories. Furthermore, when we subtracted cost from reliability to form a crude measure of "net gain" (Beach & Mitchell, 1978), we found that this "R minus C" measure offered significantly more predictive value than did cost alone, with 87% of subjects choosing the strategy with the highest “R minus C,” McNemar’s exact $p = .03$ (Odds ratio = 2.83). Mirroring the previous set of results then, these data show that although cost was a more important consideration than was reliability, subjects undoubtedly considered both attributes in determining which one of their five verification strategies to use.

Taken together, our results suggest that people consider a variety of strategies for obtaining information to verify their autobiographical memories. But people are also sensitive to both the reliability of the information they might obtain and the cost and ease of obtaining that information. When subjects chose a strategy from those available to them, cost was a more important factor than was reliability, and a combined function of reliability and cost best predicted their choices. These findings fit with Zipf’s (1949) notion of the primacy of “least effort” over reliability, and mirror the general findings found in the action literature discussed above (Sparrow & Newell, 1998).

Nevertheless, reliability and cost are by no means the only variables that could influence strategy selection. Another important consideration could be availability—that is, the likelihood that choosing a particular strategy would guarantee to unearth information. When considering a grandparent as a source for memory verification, for example, we might think not only about how trustworthy our grandma’s recollection might be, and how time-consuming it would be to visit her; we might also question whether grandma is likely to remember anything about the event at all. In the present study we asked subjects to list five strategies they might use, and so it is plausible that reasoning about strategy availability would have played a role in the ‘shortlisting’ of their five suggestions. A study in which subjects evaluate strategies that are predetermined by the experimenter rather than self-generated could shed light on how availability influences strategy-selection alongside reliability and cost.

Many of our subjects described memories of mildly upsetting events that were at least momentous enough to prevent subjects from forgetting the event. In this respect it is striking that subjects thought sparing time and effort would be more important than reliably proving or disproving whether the event occurred. We suspect that this tendency to prioritize cost over reliability when choosing between available strategies might underlie many real-world memory errors. For instance, when people seek easy-to-access information, and perhaps information that confirms an initial belief (Nickerson, 1998), then they might also miss opportunities to conclusively disprove false memories.

One interesting question is whether subjects' relative weighting of reliability and cost might shift if the memory they were verifying was of even greater emotional or personal importance. Future research should manipulate the valence or salience of the target memories to determine whether subjects are more inclined to prioritize reliability over cost when the stakes are higher. It would be informative to use a between-subjects design in which subjects provide reliability and cost ratings either before or after they indicate their likelihood of using their suggested strategies. Such a design would clarify the extent to which people naturally consider cost and reliability without being prompted to use them. Relatedly, given that we asked our subjects which strategies they thought they would use to verify a childhood memory, an important question is whether our findings would extend to the strategies they actually use.

Given that our subjects were motivated to consider both reliability and cost when choosing from the available verification strategies, it is perhaps unsurprising that most preferred not to seek physical evidence. Seeking such evidence was the only strategy perceived to involve a trade-off between reliability and cost. But as digital technology continues to replace analog, we could see people becoming increasingly reliant on physical or “virtual” forms of evidence in the future. Indeed, we frequently archive our autobiographical memories in digital photographs, online databases, blogs and microblogs. These electronic databases are packed with information that is both reliable in terms of accuracy and robustness, and cost efficient in terms of accessibility, albeit the accessibility benefit might be offset by difficulties in navigating increasing volumes of data. Although a move to relying on electronic sources implies a greater reliance on physical (or at least, “electronic”) evidence, the low cost of accessing this digital information suggests that the principal of least effort will persist.

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Footnote

[1] Note that the sign of Cost is made negative in this equation. Whereas Cost was a negative predictor of Likelihood and Reliability was a positive predictor, here we are only interested in comparing the magnitude of their correlations with Likelihood rather than the direction of those correlations.

Table 1. Standardized regression coefficients for Reliability and Cost when both were entered into linear mixed models as predictors of Likelihood, split by strategy-type (standard error in parentheses).

	Standardized regression coefficient (*b*)	
	Reliability	Cost
Family (n = 298)	.29 (.05)***	-.54 (.08)***
Others (n = 289)	.27 (.04)***	-.50 (.05)***
Physical (n = 414)	.29 (.04)***	-.66 (.04)***
Cues (n = 65)	.27 (.11)*	-.37 (.11)**
Cognitive (n = 39)	.44 (.19)*	-.35 (.22)

Note: *** $p = .001$, ** $p < .01$, * $p < .05$

Figure Caption

Figure 1. Mean reliability (left panel), cost (middle panel) and likelihood (right panel) ratings as a function of verification strategy. The error bars show 95% confidence intervals.