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Countering Method Bias in Questionnaire-Based User Studies

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Abstract

Purpose

This paper discusses reliability problems associated with questionnaires, commonly employed in library and information science. It focuses on the effects of "common method variance" (CMV), which is a form of bias, and ways of countering these effects.

Approach

We critically review the use of existing tools for demonstrating reliability in questionnaire-based studies. In particular we focus on Cronbach's alpha, "Harman's single factor test" and Lindell and Whitney's "marker variable" approach. We introduce an illustrative case study based on our own work on metacognition and web searching. We go on to make recommendations for researchers considering using a questionnaire-based approach.

Findings

CMV is a problem affecting questionnaire-based studies in different disciplines across social and information science. Where questionnaire items are more abstract, CMV has been found to be more of a problem. The widely used Cronbach alpha measure of the reliability of a questionnaire may often be affected by CMV. Where method bias dominates the results, a high alpha score may do no more than indicate that the questionnaire consistently allows participants to accede to their biases. "Harman's single factor test" is criticised as lacking sufficient foundation, and it is concluded that it should not be used. The marker variable approach is a useful option but must be applied with caution.

Practical implications

A number of practical implications for researchers are drawn. Questionnaire-based work investigating abstract constructs should be assumed to carry a high likelihood of CMV, and therefore should attempt to avoid it and demonstrate the degree of success in this regard. Otherwise, interpretation of the results should assume CMV. A number of approaches to assessing and isolating CMV are discussed.

Value

The paper draws attention to a problem that is arguably often overlooked in questionnaire-based studies, namely method bias. It discusses a number of approaches whereby it may be identified and controlled.

1. Introduction

Much research in information science entails the study of human perceptions and behaviour. Often, data concerning behaviour are sought using questionnaires in which respondents are asked to report their perceptions, preferences, attitudes or behaviour. Lau and Coiera (2008), for example, studied the effects of searchers' levels of self-reported perceived confidence on the accuracy of answers to health questions obtained through web searching, and on their susceptibility to changing their views in the light of feedback from others. Mansourian (2008) used an inventory to measure end-users' perceptions of "information visibility" on the web and of "success" and "failure" in web searching. Questionnaires are also a much-used tool more generally in the social sciences and related fields, having particular advantages in terms of low expense, wide potential reach, and ease of administration.

Despite widespread use, the use of questionnaires is not without problems. In particular, this approach may be susceptible to "common method variance" (CMV) bias. This occurs when respondents' answers to a questionnaire do not purely reflect their (intrinsic) thoughts about the phenomenon being asked about, but are influenced by the way in which the questions are asked – by (extrinsic) features relating to the design or administration of the questionnaire. Research has illustrated a variety of ways in which data obtained using questionnaires may be compromised in this way (e.g. Podsakoff *et al*., 2003). Such bias must be carefully considered in interpreting research data.

This paper addresses problems associated with CMV bias in relationship to questionnaire-based studies. After considering the nature of such bias, and ways of identifying and controlling it, the paper presents an illustrative case study relating to a study of metacognition and web searching. The structure of the paper is as follows. Section 2 below outlines the ways in which method bias can be inadvertently introduced into a questionnaire-based study. Section 3 goes on to outline existing thinking with regards to measuring and eliminating it. In section 4 we introduce a case study to illustrate the problems and possible solutions associated with method bias, based on a study investigating the role of metacognition in web searching.

2. Implicit assumptions and method bias

An important stage of any research is to identify any potential unintended contingent dependencies – particularly any untested assumptions. Dervin notes the problems associated with "tautological research methodologies in which a priori assumptions at best remain untested and at worst are simply reinforced." As Ford (2004: 1173-4) notes, Dervin warns against:

> "research methodology that is ultimately tautological to the extent that, as a perspective, it may constitute an a priori assumption that is not tested within the research. That is, it is not explicitly challenged; indeed, it may not be formulated in terms of a challengeable proposition within the research design."

and recommends:

> “the exploitation of contingent dependencies by making them the explicit focus of new research questions [...] the intention is to covert assumptions from biases to empirically testable questions.”

Such dependencies may lead to uncertainties in the form of factors, which may be potentially important in explaining the phenomenon under investigation, remaining unaccounted for in both the analysis and interpretation of data.

Such uncertainties may arise if we *assume* that:

(a) we can accurately measure subjects’ viewpoints via questionnaires (uncertainty at the level of *method*);
(b) subjects’ behaviour and perceptions will not be altered by the process of observation (uncertainty at the level of *subject/researcher interaction*); and
(c) subjects’ *self-reports* of their own behaviour describe their *actual* behaviour (uncertainty at the level of *interpretation*).

There has been considerable research focus on ways in which, regardless of topic, the questionnaire approach may be prone to inaccuracy. As noted above, common method variance (CMV) refers to the situation where the method of data gathering itself introduces a bias, leading to spuriously elevated correlations between the concepts being measured. Thus, if a questionnaire measures *stress* and *headache* using the same instrument, method bias could account for an apparent correlation. The questionnaire approach is subject to accusations of CMV, and Podsakoff *et al*. (2003) provide an exposition of the ways in which a questionnaire can produce a biased response (Table 1).

	Bias	Description
Subject-related	Consistency	Subjects try to be consistent in their response patterns
	Implicit theories	Subjects form theories about the way certain traits (for example) should relate, and answer accordingly
	Social desirability	Subjects give the answers they feel will win them approval
	Acquiescence	Subjects are disposed to agree, or disagree, regardless of the content of the items
	Mood	The subject's mood affects their responses
Item-related	Item social desirability	The wording of the item may itself convey a value judgement
	Item demand	The item may appear to "want" a particular answer
	Item ambiguity	Subject fails to interpret the question correctly
	Common scale	The scale (for example, Likert) affects responses, for example the absence or presence of a neutral or opt-out option
	Positive and negative item wording	Positively worded items way draw different responses to negative ones despite the same semantic content.
Item context	Priming	Items may acquire apparent meaning variation due to their positioning with other items
	Embeddedness	Neutral items in a positive or negative context become evaluatively "coloured" by them
	Context-induced mood	Early items create a "mood" for the remainder of the questionnaire
	Scale length	In a longer questionnaire, the subject forgets earlier items
	Grouping	Grouping items relating to the same construct may increase their apparent correlation
Measurement context	Time	Taking measurements at the same point in time may increase their covariance (for example mood effects)
	Location	Taking measurements at the same location may increase their covariance (context triggers)
	Medium	Taking measurements via the same medium may increase their covariance (for example the subject may answer differently speaking in person with an experimenter)

Table 1: Sources of method bias (adapted from Podsakoff et al., 2003)

Cronbach's coefficient alpha statistic (Cronbach, 1951) is often used as an indicator of the reliability of a questionnaire, demonstrating that subjects show the same response pattern over the duration of the questionnaire and, where results span several sessions, over time (test-retest reliability). Alpha indicates the extent of the correlation between items. However, as noted above, biases in the way subjects respond to questionnaires (CMV) may artificially inflate this coefficient alpha. Thus observed correlations may to some (unknown) extent be accounted for by CMV bias rather than representing meaningful relationships in the data. Where questionnaire-based research uses coefficient alpha and does not address the matter of CMV, there is arguably cause for concern. We suggest that where a questionnaire is at risk, but is not demonstrably free from CMV, a high coefficient alpha be treated with suspicion. This paper discusses a number of strategies to assess this risk, and to control the effects of such bias.

A substantial body of research has investigated the variation of CMV across different fields. Certain themes emerge. Crampton and Wagner (1994) show that method effects vary between research domains. Cote and Buckley (1987) found that method variance differed greatly across disciplines: 15.8% in marketing, 23.8% in other business areas (mainly management), 28.9% in psychology and sociology, and 30.5% in education. Abstract items were found to be more prone to CMV than concrete ones. Where measures are difficult or ambiguous, respondents tend to interpret them in a subjective manner, increasing:

> "random responding or […] the probability that respondents' own systematic response tendencies (e.g., implicit theories, affectivity, central tendency and leniency biases) may come into play" (Podsakoff et al. 2003, p. 883.)

Cote and Buckley (1987) showed that relatively concrete constructs such as satisfaction and performance were less associated with method effects (22.5% method variance) than were abstract constructs such as attitudes (40.7% method variance). Doty and Glick (1998) also present a large metastudy showing varying extents of CMV across studies. Lindell and Whitney (2001) further suggest that a lengthy and repetitive study may be more prone to CMV since bored subjects may look for shortcuts in their answering strategy.

3 Strategies to assess and overcome these problems

It is important to seek to produce reliable research findings in the face of these obstacles. As researchers, we can (a) assess the extent of the uncertainty, (b) design our studies to minimise the problems, and (c) take care in our interpretation of the results to restrict ourselves to what we can know. In this section we examine current thinking regarding how we can assess the extent of method bias and mitigate its impact in each of the areas of uncertainty outlined above. This section provides the necessary information to form judgements about the study presented in section 5.

3.1 Multimethod studies

Campbell and Fiske (1959) first introduced the concept of validation using the multitrait-multimethod matrix, an approach that is still in use today (see for example Muis *et al*., 2007). Key concepts introduced in their work include convergent and discriminant validation; traits are validated through being found convergent over several methods of assessment, whilst the methods of assessment are validated through being found divergent, thus less prone to sharing bias. A number of researchers have used the approach to demonstrate that CMV has not invalidated their results. However, disadvantages to the approach include the fact that the absolute result varies according to the exact methods used, and the fact that multiple methods must be used. It is of little use in assessing the impact of CMV in a single method study. It is on single-method studies that we focus here.

3.2 Single method studies

Options for assessing common method bias in a study that employs only one method are limited. “Harman's single factor test” is a widely-used option (Podsakoff and Organ, 1986, Podsakoff et al. 2003), appearing to offer the opportunity to dismiss the possibility of common method variance after the fact, without any prior planning. Podsakoff and Organ (1986) describe the technique in their widely cited paper, thus:

> The basic assumption of the technique is that if a substantial amount of common method variance is present, either (a) a single factor will emerge from the factor analysis, or (b) one “general” factor will account for the majority of the covariance in the independent criterion variables.”

A number of writers have criticised the approach (e.g. Podsakoff and Todor 1985; Lindell and Whitney 2001; Malhotra, Kim and Patil, 2006). In particular, it has been criticised as being insensitive to small or moderate levels of CMV, since the more variables there are in a study, the greater is the likelihood of finding more than one factor. Nor have clear guidelines been established on the amount of variance that has to be accounted for by the general factor, or how many other factors have to be discovered, before CMV can be ruled out (Kemery and Dunlap 1986, Podsakoff et al. 2003; P and Organ 1986).

However, the test continues to be widely cited in the context of demonstrating that an instrument is free of CMV (e.g. Bstieler and Hemmert, 2008; Carr and Kaynak, 2007; Carr and Muthusamy, 2008; Chi *et al.*, 2004; Chungtai, 2008; Darnall *et al.*, 2008; De Cuyper *et al.*, 2008; Karatepe and Magaji, 2008; Kim *et al.*, 2008; Kourteli, 2005; Malhotra *et al.*, 2006; Paulraj *et al.*, 2006; Rego *et al.*, 2007; Song *et al.*, 2006; Tang *et al.*, 2006; Thacker and Wayne, 1995; Woszczynski and Whitman, 2004; and many more).

As far as we can determine, Podsakoff and Organ (1986) is the first source to suggest applying Harman’s test to estimate CMV. However, neither they, nor any of their references, provide any explanation or justification for the assertion that method bias would manifest itself in the presence of a factor that is either *single* or *general* (in the sense of accounting for the majority of the variance).

Nor is it clear that Harman advised that the test could be used in this way [i]. The test is sometimes attributed to Harman (1967) (e.g. Kourteli, 2005, Chi *et al.*, 2004, Rego *et al.*, 2007). But Harman’s text contains suggestions for how one might determine, in the context of *confirmatory* (as opposed to exploratory) factor analysis, if a single factor model is a good fit for the data. This is not relevant to the issue of identifying and estimating CMV.

The distinction between confirmatory and explanatory factor analysis is an important one in the context of this debate. *Confirmatory* factor analysis is a way of confirming whether the data conforms to the researcher’s *a priori* expectation of the number of factors, and the way the variables load on them. *Exploratory* factor analysis is used to discover the underlying structure of the data without any *a priori* assumptions about how many factors will be found or how the variables will load on them.

Testing whether a single factor model is a good fit for the data in the context of confirmatory factor analysis is not relevant to identifying and estimating the presence of

CMV. Indeed, there does not appear to be any convincing argument, nor is it even conceptually sensible to suppose, that a single or general factor dataset is necessarily likely to be corrupted by CMV whereas a multiple-factor dataset in which there is not a single or general factor is likely to be immune. It may be that such a factor accurately reflects meaningful associations in the data.

It does, however, seem entirely reasonable to suppose that bias might manifest itself in a *pervasive*, as opposed to single or dominant general factor accounting for the majority of the variance. We define a pervasive factor as one which *correlates significantly with all items*. The rationale is that unrelated items in a questionnaire will tend to group into different factors, except where bias is present, in which case all items will show the presence of a pervasive bias factor (Lindell and Whitney, 2001). However, this does not require that a single or dominant general factor is present. It seems much more reasonable to suggest that a pervasive factor might indicate CMV than that only a single or dominant factor does so. We explore pervasive factors in more detail in section 3.3 below.

3.3 Recommendations for post-hoc mitigation in a single-method study

We are left in need of new approaches to assessing and isolating CMV post-hoc in a single method study. Although it is difficult to proceed with certainty, one heuristic would involve assessing the various indicators of the presence of CMV and forming a judgement based on several sources of evidence. One such indicator is the presence of a pervasive factor. As noted above, we propose, as a heuristic, that a pervasive factor is one which *correlates significantly with all items*. This criterion has the advantage that whilst it is conservative, inasmuch as a variable must correlate *significantly* with a factor for it to be considered a component of that factor, it has no lower limit on the extent of the variance explained. “All items” does not include concrete and unambiguous items such as age and gender, which we can assume are practically immune to bias. However, all subjective items must be included if the factor is to be considered pervasive.

We propose that CMV might be considered likely if;

- one or more pervasive factors are present *and*
    - at least one pair of items is orthogonal *or*
    - the questionnaire contains a degree of abstraction or ambiguity

Isolation of CMV is possible as follows:

- Where orthogonal items are included, CMV can be isolated for the entire instrument as the shared factors (though see below for more about post-hoc identification of marker variables).
- Where no pair of items can be considered orthogonal, non-pervasive factors only may be considered “safe”. Podsakoff and Todor (1985) make a similar suggestion.

However, in the case that one or more pervasive factors are found, but none is shared across orthogonal items (see above), it is still difficult to discern to what extent this factor is CMV and to what extent it is simply a pervasive but meaningful factor in the data.

Where a theoretically unconnected "marker variable" is included in the questionnaire ahead of time, CMV can be isolated as the covariance of the marker variable with the other questionnaire items. However, Lindell and Whitney (2001) indicate that it might be possible to perform a marker variable analysis on a study without previously having built in such a marker variable, by identifying an uncorrelated variable pair from among those already included in the study. Others (e.g. Jimmieson *et al.*, 2008, Zhang and Chen, 2008) avail themselves of this suggestion.

However, some caution must be used. It is tempting to choose the lowest correlation from among all variable pair correlations (or second-lowest, e.g. Zhang and Chen, 2008, Newkirk *et al.*, 2008), and deem this to be the extent of the CMV. However, this is not statistically sound. The correlations are subject to sampling error. The smallest correlation will almost certainly be misleadingly low. Lindell and Whitney (2001, p. 118) are clear on this point on this point; post-hoc identification of marker variables on the basis of a low correlation can only be justified where the sample is large, the number of variables is small and there is a sound theoretical basis for asserting that the variable pair is unrelated.

Otherwise, the likelihood of capitalising on chance to generate an excessively low estimate of CMV is too great. Another error that one might make would be to use a very concrete variable such as age or gender (as do Jimmieson *et al.,* 2008, Bernerth et al., 2008). Concrete items, as indicated by Cote and Buckley (1987) are less prone to CMV, so choosing an item unusually concrete compared to the rest of the instrument would give an artificially deflated estimate of the CMV in the instrument as a whole. This point is similar in intent to one made by Lindell and Whitney (2001, p. 117), in which they suggest that one should "equate the variables with respect to MV [method variance] susceptibility".

The "worst case scenario" is that we have no orthogonal items that we can treat as marker variables and the questionnaire items contain a degree of abstraction and ambiguity. In this case, to consider any pervasive factor suspect would be to potentially discard good data, as the factor may also contain variance relevant in the context of the study. As Kemery and Dunlap (1986) point out, this can render results meaningless.

We therefore suggest some post-correction techniques:

- Introducing an orthogonal marker variable to determine through new data collection the extent of CMV in the original instrument. It is possible that the presence of the marker variable might influence the extent of CMV and therefore the result might not be applicable to the original data. However, this seems a small risk.
- Conducting further work on the topic using other methods, thus extending the study to a multi-method study. Multitrait-multimethod techniques would then be applicable.

4. Case study: an investigation of metacognition in web searching

In this section we present a case study based on our own previously reported questionnaire-based study into the role of metacognition in web searching (Gorrel et al., 2008a,b). Metacognition, or “thinking about thinking”, describes, in essence, an awareness of one's own mental processes (Flavell, 1979, Brown, 1987, Metcalfe and Shimamura, 1994). It might include not only knowing what one is thinking, but evaluating the effectiveness of a thought process and potentially choosing to change it. It is clearly a highly abstract construct

Metacognition has been increasingly a focus for interest and research since the 1970s, having been implicated in a range of information processing tasks. Research has shown that it is a powerful tool in a range of learning tasks (Hill and Hannafin, 1997; Alexander & Judy, 1988; Brown et al., 1983). It has also focused on ways in which metacognition can be encouraged and facilitated – for example, through the use of “scaffolding” (Hannafin *et al.*, 1999).

Our own work took place in the context of an AHRC project investigating the role of metacognition in web searching. In keeping with a number of investigations into metacognition (e.g. O’Neil and Abedi, 1996, Schraw and Dennison, 1994, Çetinkaya, and Ertkin, 2002), we conducted a questionnaire-based study.

Previous investigations have by no means always taken CMV into account. O’Neil and Abedi (1996), in their questionnaire-based study of metacognition, make no mention of the possibility that CMV could be present in their data. Similarly, Schraw and Dennison (1994), in testing their metacognitive awareness inventory (MAI), do not consider the possibility of CMV. Self-reporting in the area of metacognition requires some very specific mental skills. The act of describing one’s own mental processes is a manifestation of metacognition in itself. Therefore, to ask subjects to say whether they use metacognition is to assume *a priori* that they have metacognitive skills to a certain extent. In this way, the questionnaire methodology is immediately open to potential bias. To pick a concrete example from the AHRC project reported below, if subjects are asked whether they plan their web searches, it is difficult to infer from a positive response whether they have good introspective skills and do plan their searches, or whether they have poor introspective skills and may or may not plan their searches.

4.1 Outline of the study

In the taxonomy outlined in Gorrell *et al.* (2008a), metacognitive skills are divided into five components: schema-training, planning, monitoring, evaluation and transfer. These five components were applied to four separate aspects of searching the web: *memory, comprehension, task and technology*. This creates a total of 20 subareas (each subarea consisting of one of the components of metacognition, applied to one of the aspects of web searching). A questionnaire was designed based on these subareas, designed to investigate subjects' perceptions of their own use of the selected metacognitive skills whilst web searching. Each subarea was covered using three questionnaire items (2 phrased positively and 1 phrased negatively), resulting in 60 questionnaire items. The questions are of a similar type to those of O’Neil and Abedi (1996) and Schraw and

Dennison (1994). The questionnaire is given in full in Appendix A. Examples of questionnaire items are shown in Table 2.

Questionnaire subareas	Illustrative questionnaire item
Schema training: *technology*	"I know how to use the functions that a search engine offers"
Planning: *task*	"Before I start my search, I tend to plan where I'm going to look for information"
Planning: *comprehension*	"I try to develop search strategies that avoid results which are too technical"
Monitoring: *memory*	"Sometimes when I'm searching, I'm aware that I might forget the information I find"
Evaluation: *task*	"I spend a lot of time judging how well the information I find matches my learning needs"
Transfer: *technology*	"I have no trouble using web searching technology because I am proficient at other similar tasks"

Table 2: Examples of questionnaire items illustrating the different aspects of metacognition investigated.

The questionnaire was implemented in the form of a web-based survey. Respondents were sought from staff and students of the University of Sheffield. 400 people from a broad range of academic disciplines were represented. Full details of the sample are given in Gorrell et al. (2008a).

4.2 Analysis of method bias in the study

The results of this study are reported in full in Gorrell et al. (2008a). However, aspects of the data analysis are reported here for the purpose of illustrating:

- evidence for the possible presence of CMV;
- the implications of CMV for generating differing interpretations of the data; and
- ways of counteracting CMV.

The first four factors revealed by the analysis are summarised below:

Factor 1 was characterised by high overall use, relative to the other factors, of metacognitive strategies. A significant positive correlation ($p = 0.002$) was found between Factor 1 and age, older people reporting more use of metacognitive strategies across all areas. This factor accounted for 22% of the variance.

Factor 2 was characterised by high confidence in relation to searching (choosing effective search terms and using search technology), remembering and understanding, with low levels of planfulness. A significant negative correlation ($p = 0.000$) was also found between Factor 2 and age, and between Factor 2 and female gender ($p = 0.006$).

Factor 3 was characterised by relatively high use of metacognitive strategies to compensate for cognitive weakness. This is, in contrast to, the general trend of the questions, which do not draw attention to cognitive weakness.

Factor 4 is characterised by high levels of planfulness in relation to searching, (featuring items such as *“I tend to work out my search strategy before I begin”*), but low use of techniques for remembering or understanding.

4.2.1 EVIDENCE FOR THE POSSIBLE PRESENCE OF METHOD BIAS

A number of features of the data suggest that the possible presence of method bias should be considered.

- The first factor described above was found to be a pervasive factor, correlating significantly with all subjective items.
- Cronbach's alpha scores were uniformly high, both for individual subscales and for the questionnaire overall. Alpha scores in all but four of these subscales were in the 0.94-1.00 range, with most being 0.98 or above. Alpha scores on memory, comprehension, task and technology amalgamated subscales also revealed scores in the 0.98-1.00 range. Scores on schema training, planning, monitoring, evaluation and transfer subscales revealed scores in the 0.94-1.00 range. The overall alpha for the entire questionnaire was 0.98. This was unexpected, since items were designed to reflect 20 subscales. For example, the subjects were asked about their memory skills, and their technical mastery. Certainly we might expect some degree of correlation between the different areas, but this does seem especially high.
- In the pre-testing of the web survey we included a response box in which respondents could record any comments they had relating to the questionnaire. Some of the comments made by respondents indicated anecdotally that they found themselves subject to compromising issues:

  “As I do this section I’m very aware I may not be entirely consistent with my earlier answers...”

  “I truly do not know much about my cognitive processes. I am not able to verbalize what goes on in my mind”

The first quotation reflects the “consistency” type of potential bias listed in Table 1. The theory behind this is that subjects “might search for similarities in the questions asked of them—thereby producing relationships that would not otherwise exist at the same level in real-life settings” (Podsakoff *et al.*, 2003). The second quotation reflects the respondent’s belief that (although the questionnaire did offer a “don’t know” category in the Likert responses) s/he did not feel that s/he possessed the information that was being asked for. Three users also explicitly commented on the abstract nature of the subject matter, saying that this made it difficult for them to understand exactly what we meant in some cases. Abstract subject matter has been identified as potentially leading to a higher degree of CMV (Cote and Buckley, 1987).

The fact that the first factor was a *pervasive* factor (correlating significantly with all subjective items), the abstract nature of the phenomenon being investigated, and the high Cronbach alpha scores, suggest that the presence of CMV is both possible and likely. We must therefore concede that significant CMV is a possibility.

4.2.2 THE IMPLICATIONS OF METHOD BIAS FOR GENERATING DIFFERING INTERPRETATIONS OF THE DATA

Conclusions made without taking into account the possibility of CMV may differ considerably from those made in the light of CMV assessment. Thus where CMV is possible and cannot be ruled out or isolated, appropriate caution must be exercised in interpreting results and drawing conclusions. In the case of the metacognition study described here, there is a risk that the conclusion that older people make greater use of metacognitive strategies than do younger people is subject to doubt. This is because it is based on a correlation between age and the first (pervasive) factor. In fact, it could be that older people are simply more prone to CMV. On the other hand, the conclusion that males are less likely to engage in planning activity would seem to be more secure in that it is based on a correlation between a non-pervasive factor (factor 2) and a concrete variable (gender). It is therefore unlikely to be compromised by CMV.

By no means all other studies that have investigated metacognition using questionnaires have taken CMV into account in their interpretations and conclusions. For example, O'Neil and Abedi (1996) show a similar pattern of results in their own questionnaire-based study of metacognition. They find a high coefficient alpha. They varied the length of their questionnaire, and found the shorter version had the higher alpha. They did not consider the presence of CMV; however, factor analysis revealed one dominant factor. Similarly, Schraw and Dennison (1994) find a high overall coefficient alpha in testing their metacognitive awareness inventory (MAI), and find that most items load onto the first two factors. Again, CMV was not considered. The presence of possibly pervasive factors, in conjunction with the abstract subject matter, raises the possibility of significant CMV. Note however that Çetinkaya and Ertkin (2002) appear not to have pervasive factors in their results, despite the fact that their metacognition inventory was based on those of O'Neil and Abedi (1996) and Schraw and Dennison (1994). Without being able to examine the actual inventory it is difficult to draw conclusions from this.

4.3.3 WAYS OF COUNTERACTING METHOD BIAS

A number of strategies for dealing with method bias suggested were suggested in section 3. One approach is to attempt to isolate its effects via further analysis of data already collected. In the absence of a marker variable in our metacognition study, it is impossible to estimate the extent of method bias in the questionnaire responses. No item pair was found suitable for *post-hoc* marker variable analysis, as all subjective items might be expected to correlate to a certain extent.

Without engaging in further data analysis, there is no means to isolate the effects of CMV via further analysis of the existing data. It would therefore be sensible to focus our analysis on non-pervasive factors and concrete items, as suggested in the previous section.

Another approach is to attempt to enable its effects to be isolated via the collection of new data. Options include adding a marker variable and collecting further data, and/or collecting further data via other methods.

5 Discussion and conclusions

CMV has been shown to be a problem to varying degrees in different disciplines across social and information science (Cote and Buckley, 1987). Where questionnaire items are more abstract, CMV has been found to be more of a problem.

This paper has discussed the advantages and disadvantages of several methods of quantifying CMV. We find the widely-used “Harman’s single factor test” to be without foundation. We conclude that where only one method has been used to collect data in a study (i.e. a questionnaire alone), the marker variable approach (Lindell and Whitney, 2001) is a better option for quantifying and excluding CMV. Options exist for applying the technique *post-hoc*. We draw attention to the fact that it is not valid to choose a marker variable pair from existing questionnaire items on the basis that that pair is found to have a low correlation, or if one or both items are unusually concrete compared with the rest of the questionnaire (e.g. age).

We ask the question, does a high coefficient alpha score really mean anything in the absence of an estimate of CMV? Where bias dominates the results, a high coefficient alpha score may do no more than indicate that the questionnaire consistently allows participants to accede to their biases.

Implications for future work are as follows:

- Questionnaire-based work investigating abstract constructs (such as metacognition) should be assumed to carry a high likelihood of CMV, and therefore should either take pains to avoid it and demonstrate the degree of success in this regard, or else assume CMV in the interpretation of the results and avoid focusing on correlations with pervasive factors.
- Coefficient alpha should be used in conjunction with an estimate of CMV.
- “Harman’s single factor test” should not be used.
- Where only one method has been used to collect data in a study (i.e. a questionnaire alone), the marker variable approach is a good option for quantifying and excluding CMV.
- Options exist for applying the technique *post-hoc*.
- Care should be exercised when choosing marker variables *post-hoc*. A marker variable pair should not be drawn from existing questionnaire items on the basis of a low correlation, or if one or both items are unusually concrete compared with the rest of the questionnaire.

- Where possible, precautions against CMV should be built into a study's research design from the beginning. Where appropriate, for example, during pilot testing, it may be useful to gather data from respondents on their perceptions of the questionnaire itself. Consideration should be given to the use of different data gathering methods in order to achieve a degree of triangulation.

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Appendix A: The metacognition questionnaire

Key to question topic codes:

	Memory	Comprehension	Task	Technology
Schema-Training	[S-M]	[S-C]	[S-Ta]	[S-Te]
Planning	[P-M]	[P-C]	[P-Ta]	[P-Te]
Monitoring	[M-M]	[M-C]	[M-Ta]	[M-Te]
Evaluation	[E-M]	[E-C]	[E-Ta]	[E-Te]
Transfer	[T-M]	[T-C]	[T-Ta]	[T-Te]

1. I've got ways to help me remember information sources I find. [S-M]
2. I have techniques that help me understand the information I find when searching. [S-C]
3. When I have a learning task, I usually know how to decide on the type of information I need. [S-Ta]
4. I've developed ways of identifying the type of information I need for my learning tasks. [S-Ta]
5. I know how to use the functions that a search engine offers. [S-Te]
6. I am good at choosing words that tell a search engine what I'm looking for. [S-Te]
7. I have techniques that help me remember the information I find. [S-M]
8. I am confident that I have a good approach to recalling what I need from a search. [E-M]
9. When I am about to start a new search for information, I apply lessons I have learned from previous searches. [P-M]
10. A search strategy that did not yield good results can provide valuable lessons for future searches. [M-Te]
11. My experience from other areas helps me to work out exactly what type of information I need for my learning task. [T-Ta]
12. I don't find that techniques from other areas of learning help me to decide what will be useful. [T-Ta-N]
13. I have no trouble using web searching technology because I am proficient at other similar tasks. [T-Te]
14. My proficiency in other tasks doesn't help me to search. [T-Te-N]
15. The skills that I use when web searching are useful in other areas of my life. [T-Te]
16. Sometimes, procedures that have proved useful in other tasks help me to work out what information I need. [T-Ta]
17. I use approaches to recalling the information that I learned in other domains. [T-M]
18. When I search, I don't use techniques for remembering information that I learned in other tasks. [T-M-N]
19. My experience with a range of learning tasks has helped me monitor how well I am understanding what I read. [T-C]
20. Past experience from learning tasks does not help me to assess my comprehension in new tasks. [T-C-M]
21. Sometimes I feel that my search might have gone better if I'd been better able to understand what I read. [E-C]
22. The ways I remember the information I find are also useful in other tasks. [T-M]

23. I plan ways to remember the information I find. [P-M]
24. I don't think about how I will remember the information I find - I just get straight on with my search. [P-M-N]
25. I don't give much thought beforehand to ways I can improve my understanding. [P-C-N]
26. Before I start my search, I tend to plan where I'm going to look for information. [P-Ta]
27. Before beginning a Web search, I work out which words I'm going to enter in the search box. [P-Te]
28. I tend to work out my search strategy before I begin. [P-Te]
29. I decide in advance exactly what type of information I'm looking for. [P-Ta]
30. When I have a learning task, I usually think carefully about the type of information I need for it. [M-Ta]
31. I often don't know whether the search terms I am using are likely to produce a good result. [E-Te-N]
32. I may start a search task by focusing on increasing my understanding of the subject area. [P-C]
33. I don't really have any particular procedures for helping me to remember the information I find. [S-M-N]
34. Sometimes the information I find is hard to understand. [S-C]
35. I don't have any particular techniques for improving my understanding of what I find when searching. [S-C-N]
36. I often use different searching approaches depending on the particular goal I have. [S-Te]
37. I try to develop search strategies that avoid results which are too technical. [P-C]
38. I don't think about which words to put into a search box until the search is underway. [P-Te-N]
39. Sometimes when I'm searching, I'm aware that I might forget the information I find. [M-M]
40. When I'm searching, I tend not to think about how well I understand what I read. [M-C-N]
41. I think a lot about why I am doing things as I search (e.g. the words I put into the search box). [M-Te]
42. When I'm seeking information for a learning task, I find myself asking something along the lines of: "Is this search providing the type of information I need?" [M-Ta]
43. I tend to search without thinking a lot about why I'm taking each action. [M-Te-N]
44. It is clear to me when I am failing to remember what I learned. [E-M]
45. I often don't know whether I will be able to remember what I later need. [E-M-N]
46. It is unclear to me how well I understand what I read. [E-C-N]
47. I can tell whether the words I use in my searches are good ones. [E-Te]
48. It is usually obvious to me whether I am using a good search strategy or not. [E-Te]
49. I give little thought to how well a search will satisfy my learning needs. [E-Ta-N]
50. I ask myself, when I'm searching, if I'm going to be able to remember the information later. [M-M]
51. Sometimes it occurs to me that I may have misunderstood something I read earlier in my searching. [M-C]

52. As I search, I judge how well I understand what I find. [M-C]
53. When I have a learning task to perform, I don't have clear procedures for deciding what type of information I need. [S-Ta-N]
54. I tend to decide what's relevant and what isn't based on criteria that emerge during the search. [P-Ta-N]
55. Sometimes I find some useful information but can't remember where I found it. [M-M-N]
56. I don't spend much time assessing how well the information I'm finding meets the requirement of my learning task. [M-Ta-N]
57. I clearly know when I understand and when I don't. [E-C]
58. I spend a lot of time judging how well the information I find matches my learning needs. [E-Ta]
59. I don't think much about whether my search was effective in providing the right sort of information for my learning task. [E-Ta-N]
60. Assessing the information in a web search is a similar skill to assessing information in other contexts. [T-C]

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[i] Podsakoff and Organ (1986) appear to be the first source to suggest applying the test as a means of estimating CMV. They cite a number of other authors as using the technique in this way, including Greene and Organ (1973), C. Schriesheim (1979) and J. Schriesheim (1980) and Podsakoff *et al.* (1984). Greene and Organ do cite use of Harman's single factor test, but not to estimate CMV. They cite the work of Brewer, Campbell and Crano (1970), in which the case is made that partial correlations can give the misleading impression of multiple factors in the case where error is present in data. They recommend ruling out the possibility of a single factor solution before concluding that multiple factors are present, and use Harman's single factor test to accomplish this. Their work is rooted in confirmatory factor analysis, to which, as noted above, Harman's test relates (Malhotra, Kim and Patil, 2006). Ruling out a single factor solution has no relevance to quantifying CMV. Podsakoff and Organ also cite C. Schriesheim (1979) and J. Schriesheim (1980) as using the test to estimate CMV. Again, C. Schriesheim merely cites Harman in the context of determining the appropriate number of factors. However, J. Schriesheim does mention the absence of a general factor as an indicator of the absence of CMV, as do Podsakoff *et al.* (1984).