Source Monitoring:
Source-Memory Effects and Guessing Strategies

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Eigenständigkeitserklärung

Ich versichere an Eides Statt, dass die Dissertation von mir selbständig und ohne fremde unzulässige Hilfe unter Beachtung der „Grundsätze zur Sicherung guter wissenschaftlicher Praxis an der Heinrich-Heine-Universität Düsseldorf" erstellt worden ist.

Des Weiteren versichere ich, dass die vorliegende Arbeit selbständig verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel benutzt wurden. Alle wörtlich oder dem Sinn nach aus anderen Texten entnommenen Stellen sind als solche kenntlich gemacht. Die Dissertation enthält keine Teile (Textpassagen, Grafiken etc.) von Arbeiten anderer Personen.

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Zusammenfassung

In sieben Experimenten wurden die Vorhersagen zweier Hypothesen bezüglich des Einflusses von Aufmerksamkeit auf das Quellengedächtnis sowie dreier Ratehypothesen bezüglich Ratestrategien bei Quellengedächtnisaufgaben untersucht.

Hinsichtlich des Einflusses zusätzlicher Aufmerksamkeit auf das Quellengedächtnis postuliert die *Aufmerksamkeitshypothese* (AEH) ein besseres Quellengedächtnis für untypische Quellen wohingegen die *Theorie visueller Aufmerksamkeit* (TVA) ein besseres Quellengedächtnis für Quellen mit besonderen Eigenschaften vorhersagt. In fünf Experimenten konnten beide Hypothesen bestätigt werden: Bei der Verwendung einer gleichen Anzahl an typischen und untypischen Quellen sowie einer größeren Anzahl an typischen als untypischen Quellen zeigte sich, wie von AEH und TVA postuliert, ein besseres Quellengedächtnis für untypische Quellen. Des Weiteren zeigte sich bei der Verwendung einer größeren Anzahl untypischer als typischer Quellen kein Quellengedächtnisunterschied, da in diesem Fall die AEH ein besseres Gedächtnis für untypische Quellen und die TVA ein besseres Gedächtnis für typische Quellen vorhersagt.

Hinsichtlich angewandter Ratestrategien bei Quellengedächtnisaufgaben postuliert die *schemabasierte Ratehypothese* schemakonsistentes Raten, die *kompensatorische Ratehypothese* Raten, welches das schlechte Gedächtnis für eine Quellenart kompensiert und die *kontingenzbasierte Ratehypothese* Raten, das sich an der wahrgenommenen Kontingenz orientiert. In vier Experimenten konnte die schemabasierte Ratehypothese bestätigt und sowohl die kompensatorische als auch die kontingenzbasierte Ratehypothese zurückgewiesen werden: Während sich in Experiment 1 und 3 kein Rateverhalten zeigte, das sich an der wahrgenommenen Kontingenz orientierte, fehlte in Experiment 6 und 7 ein kompensatorischer Rateprozess, der das bessere Quellengedächtnis für typische Quellen kompensierte.

Abstract

In seven source-monitoring experiments, we tested predictions of two hypotheses concerning influences of attention towards source-memory performance as well as predictions of three guessing hypotheses concerning source-guessing strategies.

Concerning source memory, the *attention-elaboration hypothesis* (AEH) proposes better source memory for unexpected sources due to attention drawn to these sources whereas the *theory of visual attention* (TVA) proposes better source memory for sources with special features due to attention drawn to these sources. Both hypotheses were supported in five experiments: As AEH and TVA predict better source memory for unexpected sources using the same ratio of expected and unexpected sources as well as more expected than unexpected sources, inconsistency effects with better source memory for unexpected sources occurred. As AEH predicts better memory for unexpected sources and TVA predicts better memory for expected sources using more unexpected than expected sources, no inconsistency effects but equal source memory for expected and unexpected sources occurred.

Concerning guessing strategies, the *schema-based guessing hypothesis* proposes schema-consistent guessing, the *compensatory-guessing hypothesis* proposes guessing compensating for poor memory of one source category, and the *contingency-based guessing hypothesis* proposes guessing orienting on perceived contingencies. In four experiments, the schema-based guessing hypothesis was supported and both compensatory-guessing hypothesis and contingency-based guessing hypothesis were refuted: The contingency-based guessing hypothesis could not explain schema-consistent guessing not reflecting the perceived 50:50 contingency (Experiment 1 and 3) and the compensatory-guessing hypothesis could not explain schema-consistent guessing not compensating for better source memory for expected sources (Experiment 6 and 7).

1 Introduction

Every day we need to solve memory tasks like we should remember the name of a new colleague, buy milk on the way home, or call a friend on his birthday. Sometimes it is even important to remember the source of information besides the information itself (Bayen, Nakamura, Dupuis, & Yang, 2000). Such sources could be a person telling you something, a place we left our glasses or keys that we are now looking for, or a medium like a newspaper where we read an article or the news we listened. Sometimes the source of information is deciding. Whereas it could be essential for survival to take some medicine if our doctor told us to, it could be unimportant to take it if our colleague told us to just because he takes it as well. Therefore, not the information itself (“take this medicine”) but the source of information (our doctor or colleague) decides whether we should follow the advice or not. In conclusion, we need to remember the source of information to judge how important, useful or trustworthy the information is.

Johnson, Hashtroudi, and Lindsay (1993) defined these “processes involved in making attributions about the origins of memories, knowledge, and beliefs” (p. 3) as *source monitoring*. It includes memory and guessing processes. In conclusion, correct source identification can occur due to correct source memory or correct guessing. For example, we could remember that our doctor told us to take the medicine or we could just guess that our doctor told us to take the medicine because it is plausible.

A typical source-monitoring paradigm consists of two parts: At study, items originating from two or more sources were presented (e.g., statements presented by different speakers). At test, items from study list and new items were presented. Participants indicate if a test item is new or which source presented the item.

2 Measuring Source Monitoring

Data from source-monitoring tests can be presented in 3x3 tables in which rows represent sources the items were presented with and columns represent responses made by the participants. Table 1 illustrates such a raw data table.

Table 1

Data structure from source-monitoring experiments

	Response		
Source	"A"	"B"	"N"
A	Y_{AA}	Y_{AB}	Y_{AN}
B	Y_{BA}	Y_{BB}	Y_{BN}
N	Y_{NA}	Y_{NB}	Y_{NN}

Note. Responses are in quotation marks. A = Source A, B = Source B, N = new item (not presented in study). Y_{ij} = frequency of responses of type *j* to items of type *i*.

The raw data can be analyzed by different measures and methods. Empirical measures separate item identification from source identification revealing measures for source identification including source memory and source-guessing processes (Murnane & Bayen, 1996). Multinomial models of source monitoring separate item memory, source memory, and guessing revealing pure measures for item memory, source memory, and guessing processes (Batchelder & Riefer, 1990).

2.1 Empirical Measures of Source Identification

If source-monitoring performance should be investigated, empirical measures offer an adequate solution. Murnane and Bayen (1996) investigated which measures do not confound item and source identification. They found that the single-source *conditional source identification measure* (CSIM) should be used for comparisons between individual sources, while the average conditional source identification measure (ACSIM) should be used for comparisons between pairs of sources. The most commonly used CSIM for Sources A and B is calculated as follows

$$CSIM_A = \frac{Y_{AA}}{Y_{AA} + Y_{AB}}$$

$$CSIM_B = \frac{Y_{BB}}{Y_{BA} + Y_{BB}}$$

with Y_{ij} indicating the frequency of responses of type *j* to items of type *i* (Bayen et al., 2000). Research using empirical measures concentrates on source identification as a sum of source memory and guessing. It is not important whether answers were made due to remembering or guessing. Bayen et al. (2000) stated in their performance hypothesis that schema-consistent information (as a doctor talking about medicine) should lead to better source identification than schema-inconsistent information (a doctor talking about flying a plane) or neutral information (a doctor talking about the weather). They tested and supported their performance hypothesis via empirical measures (CSIM and ACSIM) revealing better source identification for schema-consistent than schema-inconsistent information.

2.2 Multinomial Models of Source Monitoring

Empirical measures confound source memory and guessing biases, whereas multinomial models of source monitoring separate item memory, source memory, and guessing biases (Batchelder & Riefer, 1990). Multinomial models assume that responses made by participants emerge from a combination of different cognitive states (Bayen et al., 2000). The probability of these cognitive states is represented by a parameter in the model and is calculated due to maximum-likelihood parameter estimation (Hu & Batchelder, 1994).

Bayen, Murnane, and Erdfelder (1996) compared three different kinds of multinomial processing tree models of source monitoring. Parameter validation showed that only the *two-high-threshold multinomial model of source monitoring* (2HTSM; Bayen et al., 1996) provided an accurate analysis of the data. In the past years, source-monitoring researchers routinely applied the 2HTSM illustrated in Figure 1 to source-monitoring data (Bayen & Kuhlmann, 2011; Bayen et al., 2000; Bell, Buchner, Erdfelder, Giang, Schain, & Riether, 2012; Bell, Buchner, Kroneisen, & Giang, in press; Bell, Buchner, & Musch, 2010; Buchner, Bell, Mehl, & Musch, 2009; Dodson, Darragh, & Williams, 2008; Ehrenberg & Klauer, 2005; Erdfelder & Bredenkamp, 1998; Keefe, Arnold, Bayen, McEvoy, & Wilson, 2002; Klauer & Meiser, 2000; Kuhlmann, Vaterrodt, & Bayen, 2012; Meiser, Sattler, & von Hecker, 2007; Spaniol & Bayen, 2002; Yu & Bellezza, 2000).

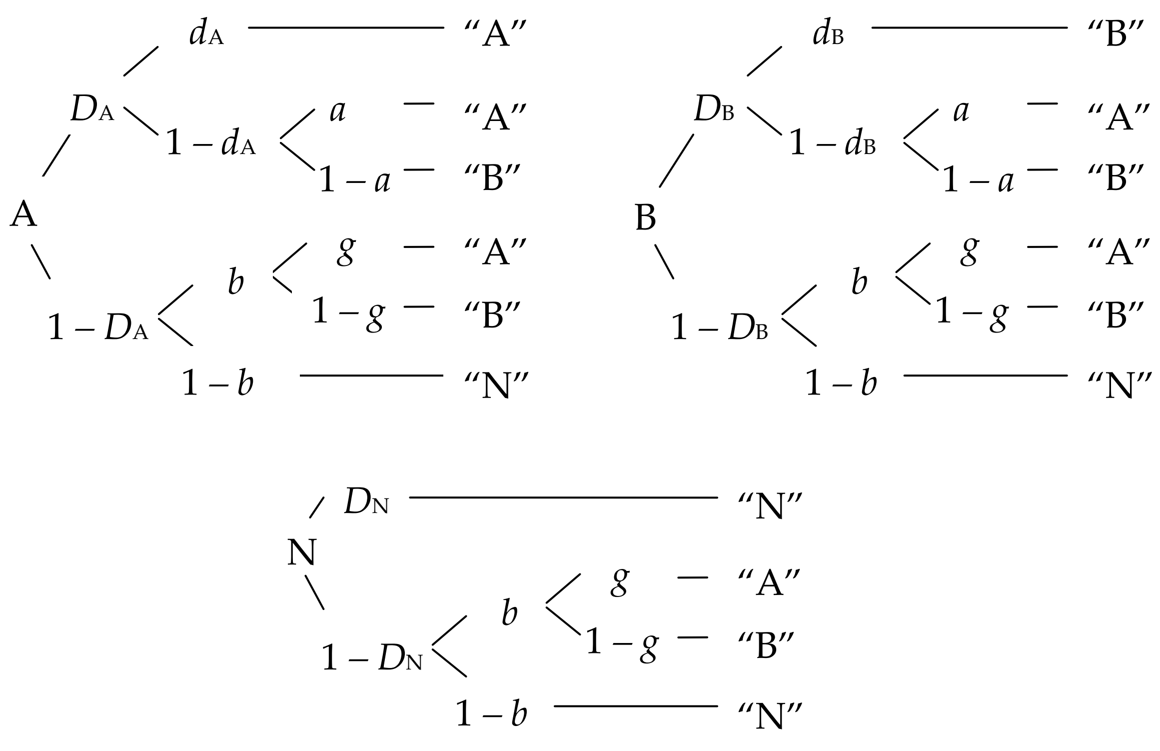

Figure 1. 2HTSM for two sources (Bayen et al., 1996). A = Source A, B = Source B, N = new item. Participant responses are in quotation marks. D_A = probability of recognizing an item that had been presented by Source A; D_B = probability of recognizing an item that had been presented by Source B; D_N = probability of knowing that a new item is new; d_A = probability of remembering that an item had been presented by Source A; d_B = probability of remembering that an item had been presented by Source B; a = probability of guessing that a recognized item had been presented by Source A; g = probability of guessing that an unrecognized item had been presented by Source A; b = probability of guessing that an unrecognized item is old. Adapted from "Source discrimination, item detection, and multinomial models of source monitoring," by U. J. Bayen, K. Murnane, and E. Erdfelder, 1996, *Journal of Experimental Psychology: Learning, Memory, and Cognition, 22,* p. 202, Figure 3. Copyright 1996 by the American Psychological Association.

In typical source-monitoring tasks using two sources, an item is presented with Source A, Source B, or it is new (N). At test, participants' responses can be "Source A," "Source B," or "neither." The first tree in Figure 1 represents items that were presented with Source A at study. Participants correctly recognize these items as old items with probability D_A. With probability d_A, they additionally remember the source these items were presented with (Source A) and correctly answer "Source A." With probability $1 - d_A$, participants cannot remember the source and guess. With probability a, they guess Source A; with complementary probability $1 - a$, they guess Source B. Participants do not recognize items as old with probability $1 - D_A$. With probability b, they guess that items are old; with probability $1 - b$, they guess that items are new. When guessing that items are old, participants guess a source as well. With probability g, they guess Source A; with complementary probability $1 - g$, they guess Source B.

The second tree represents items that were presented with Source B indicated by index B. The third tree represents new items indicated by index N. For new items, participants know that these items were not presented in study list with probability D_N. With probability $1 - D_N$, they do not know that items are new. With probability b, they guess that items are old; with probability $1 - b$, they guess that items are new.

Hypotheses concerning differences in item memory, source memory or guessing biases can be tested via parameter restrictions. Additionally, significance tests concerning parameter values like guessing on chance level (g = .50) can be carried out. If the model fit indicated by the asymptotically χ^2-distributed goodness-of-fit index G^2 (Hu & Batchelder, 1994) significantly decreases due to parameter restriction, the difference is significant.

The model shown in Figure 1 is not mathematically identifiable because there are more free parameters than degrees of freedom in the data. All identifiable submodels of the 2HTSM for two sources are shown in Table 2 and can be constructed via equality restrictions (Bayen et al., 1996). Model fit shows if underlying assumptions made by parameter restrictions of different submodels are valid. Additionally, submodels can be tested against each other by comparing model fits (Bayen et al., 2000).

Table 2

Identifiable submodels of the 2HTSM for two sources

Model 6a	Model 6b	Model 6c	Model 6d
D_B, $D_A = D_N$	D_A, $D_B = D_N$	D_B, $D_A = D_N$	D_A, $D_B = D_N$
$d_A = d_B$	$d_A = d_B$	d_A, d_B	d_A, d_B
a, g	a, g	$a = g$	$a = g$
b	b	b	b
Model 5a	**Model 5b**	**Model 5c**	**Model 5d**
$D_A = D_B = D_N$	D_B, $D_A = D_N$	D_A, $D_B = D_N$	$D_A = D_B = D_N$
$d_A = d_B$	$d_A = d_B$	$d_A = d_B$	d_A, d_B
a, g	$a = g$	$a = g$	$a = g$
b	b	b	b
Model 4			
$D_A = D_B = D_N$			
$d_A = d_B$			
$a = g$			
b			

Note. Equal signs indicate equality restrictions of parameters. D_A = probability of recognizing an item that had been presented by Source A; D_B = probability of recognizing an item that had been presented by Source B; D_N = probability of knowing that a new item is new; d_A = probability of remembering that an item had been presented by Source A; d_B = probability of remembering that an item had been presented by Source B; a = probability of guessing that a recognized item had been presented by Source A; g = probability of guessing that an unrecognized item had been presented by Source A; b = probability of guessing that an unrecognized item is old. Adapted from "Source discrimination, item detection, and multinomial models of source monitoring," by U. J. Bayen, K. Murnane, and E. Erdfelder, 1996, *Journal of Experimental Psychology: Learning, Memory, and Cognition, 22,* p. 202, Figure 4. Copyright 1996 by the American Psychological Association.

Data analyses usually start with the most parsimonious submodel (Model 4 with four parameters). If Model 4 cannot be used for data analysis indicated by a poor model fit, next submodels with five parameters will be tested (Model 5a, 5b, 5c, and 5d). If again poor model fit exists, submodels with six parameters will be used.

Batchelder and Riefer (1990) mathematically showed that some of the submodels always fit data the same way and cannot be empirically tested against each other by comparing model fits. Such models are Model 5a, assuming equal source memory but different source guessing biases for recognized and unrecognized items, and Model 5d, assuming different source-memory parameters for Source A and B but no difference in source guessing. Applying one of these submodels for data analysis cannot definitely reveal whether differences in source memory or guessing biases exist.

As a solution to this methodological dilemma, Riefer, Hu, and Batchelder (1994) presented a 2HTSM for three sources instead of two sources. Such model for three sources offers more degrees of freedom, enabling researchers to separately estimate parameters for different types of source memory and guessing processes. This model allows researchers to test empirically if differences in source memory, differences in guessing, or both exist. Additionally, we developed an experimental setup using two instead of three sources that offers an alternative way of verifying if source-memory differences exist (Küppers & Bayen, 2012). By manipulating guessing biases via payoffs, source-memory differences can be revealed if existing. In conclusion, this design-based approach provides the opportunity to compare the appropriateness of submodels stating differences in source memory versus guessing processes, respectively.

3 Source-Memory Effects

Sometimes it is very important to be able to distinguish answers made due to correct source memory from answers made due to source guessing. For example concerning court testimony, memory-based answers are more trustworthy and useful than guessing-based answers. Therefore, source memory and conditions influencing source-memory performance should be investigated separately from source guessing.

3.1 Theoretical and Empirical Background

In everyday life, we use stereotypes, schemas, and general knowledge to organize, judge, and use information (Alba & Hasher, 1983). Whereas information fitting in an existing schema does not extend our knowledge that much, new and unusual information attract attention: When our doctor tells us that he does extreme sports on weekends, we may remember this information because it is that extraordinary, surprising and not fitting in our schema of a doctor. In contrast, the same doctor telling us that he is vegetarian and places great value on healthy eating is not that surprising and the information may be remembered less.

3.1.1 Attention-Elaboration Hypothesis

The *attention-elaboration hypothesis* (AEH; Brewer & Treyens, 1981; Friedman, 1979; Loftus & Mackworth, 1978) proposes better memory for such surprising, schema-inconsistent information. Schema-inconsistent information attracts more attention and is processed more deeply than schema-consistent information. It should be easier to retrieve and recognize. Such better memory for schema-inconsistent than schema-consistent information is called *inconsistency effect* (Ehrenberg & Klauer, 2005).

Whether information is schema consistent or schema inconsistent, the source of information is decisive. The same statement can be schema consistent, schema inconsistent or neutral in combination with different sources. In conclusion, better source memory for unexpected sources than expected sources as predicted by the AEH should exist (Bayen et al., 2000; Ehrenberg & Klauer, 2005). In fact, literature shows mixed results concerning inconsistency effects in source memory: Bayen and Kuhlmann (2011), Dodson et al. (2008), Kuhlmann et al. (2012) and Spaniol and Bayen (2002) found no inconsistency effects with equal source memory for expected and unexpected sources; Bayen et al. (2000; Experiment 1) found a non-significant advantage for unexpected sources; Ehrenberg and Klauer (2005) found an inconsistency effect with better source memory for unexpected sources limited to the condition with greatest task difficulty; and Gawronski, Ehrenberg, Banse, Zukova, and Klauer (2003) found an inconsistency effect in source memory for strong but not for weak stereotypic associations.

A possible reason for these results was mentioned by Stangor and McMillan (1992). They found a connection between expectancy strength and the occurrence of inconsistency effects in their meta-analysis, in which a low level of expectancy decreased inconsistency effects. Source-monitoring studies using material with low expectancy strength indicated by imprecise person schemas and somewhat unexpected instead of very unexpected items found no inconsistency effects (Bayen & Kuhlmann, 2011; Bayen et al., 2000; Dodson et al., 2008; Ehrenberg & Klauer, 2005; Kuhlmann et al., 2012; Spaniol & Bayen, 2002). In line Gawronski et al. (2003) found that persons with strong stereotypical beliefs showed inconsistency effects with better source memory for unexpected sources, whereas persons with weak stereotypical beliefs showed no memory differences in source memory.

To test whether inconsistency effects in source memory as predicted by the AEH exist, material with high expectancy strength is needed. Such material with high expectancy strength includes very expected and very unexpected items as well as distinctive and precise source schemas (e.g., room schemas instead of person schemas).

3.1.2 Theory of Visual Attention

Besides the AEH, another theory proposes influences of attention towards source-memory performance. The *theory of visual attention* (TVA; Bundesen, 1990) states that if one object has a special feature (e.g., large size) in contrast to other objects (e.g., small size), the object with special feature attracts more attention than the other objects. In conclusion, such objects are processed more deeply at encoding and should be easier to retrieve and recognize at test.

Fine and Minnery (2009) found memory advantages for objects with special features because of additional attention drawn to such objects at encoding as predicted by the TVA. In line, Klauer, Wegener, and Ehrenberg (2002) found better source-memory performance for a person stereotype as relative group size of this stereotype decreased. They used one man and seven women (and vice versa, one woman and seven men) as sources and neutral statements as items. Source memory for the single man was better than for the women as well as source memory for the single woman was better than for the men.

In conclusion, the ratio of different types of sources (e.g., women and men) seems to influence attention drawn to the sources. As a result, the ratio of expected and unexpected sources should influence source-memory performance, too. Whereas the TVA predicts no source-memory differences between expected and unexpected sources using the same number of expected and unexpected sources (e.g., one expected and one unexpected source), different numbers of expected and unexpected sources should influence source memory. Using three instead of two sources, the number of expected and unexpected sources varies. The TVA predicts better source memory for expected sources using one expected and two unexpected sources, while it predicts better source memory for unexpected sources using one unexpected and two expected sources. The ratio of expected and unexpected sources seems to be decisive for source-memory performance.

3.2 Overview of the Studies

We tested predictions of the AEH and TVA in five experiments. We used material with high expectancy strength indicated by very expected and very unexpected object labels as items and distinctive scene schemas as sources. Expectancy strength was determined by norming studies in all experiments.

In Experiment 1, 2 and 3, there was one expected and one unexpected source. In this experimental setting, the AEH proposes better source memory for the unexpected source. Additionally, the TVA proposes no source-memory difference between expected and unexpected sources because none (or both) of the sources has a special feature. In sum, we predicted an inconsistency effect with better source memory for unexpected sources.

In Experiment 4 and 5, we used three sources varying the ratio between expected and unexpected sources. Whereas Experiment 4 used one expected and two unexpected sources, Experiment 5 used two expected and one unexpected source. In Experiment 4, the AEH proposes better source memory for the unexpected source, whereas the TVA proposes better source memory for the expected source because of attention drawn to the source with special feature. As result, the expected source and unexpected source receive additional attention as predicted by the TVA and AEH, respectively. No inconsistency effects in source memory but equal source memory for expected and unexpected sources are predicted.

In Experiment 5, AEH and TVA propose better source memory for the unexpected source due to additional attention. Whereas the AEH still predicts better source memory for the unexpected source because of attention drawn to unexpected information, the TVA predicts better source memory for the unexpected source because of attention drawn to the source with special feature. As a result, an inconsistency effect in source memory should occur.

3.2.1 Experiment 1

In Experiment 1, we used “kitchen” and “bathroom” as sources and objects that were very expected for a kitchen and very unexpected for a bathroom, and objects that were very expected for a bathroom and very unexpected for a kitchen as items. For data analysis, we applied the 2HTSM for two sources (Bayen et al., 1996). As already mentioned, a submodel assuming source-memory differences between expected and unexpected sources (Model 5d) and a submodel assuming differences in guessing biases between recognized and unrecognized items (Model 5a) always have same model fit (Batchelder & Riefer, 1990). Based on multinomial modeling, we could not decide which submodel was the appropriate one to analyze the data. In line with predictions of the AEH, we used Model 5d assuming source-memory differences. We found an inconsistency effect in source memory with better source memory for unexpected than expected sources as proposed by the AEH.

3.2.2 Experiment 2

We performed Experiment 2 to test if Model 5d was the appropriate model to analyze data from Experiment 1. Therefore, we used materials from Experiment 1 as well as a design-based approach instead of multinomial modeling. We separated source memory and guessing bias via pay-off manipulation. Whereas correct responses gained money, incorrect responses cost money. In Condition 1, “unexpected source” responses had high costs when chosen erroneously, while “expected source” responses had low costs when chosen erroneously. In Condition 2, costs were reversed: “Expected source” responses had high costs when chosen erroneously, while “unexpected source” responses had low costs when chosen erroneously. In conclusion, responses with high costs should be less influenced by guessing (Maddox & Bohil, 2000).

We measured source-memory performance as the proportion of correct responses on a two-alternative forced choice test (with response options “expected source” and "unexpected source"). In Condition 1, source memory for the unexpected source was measured because the response option "unexpected source" had high costs. In Condition 2, source memory for the expected source was measured because the response option "expected source" had high costs. The comparison of Condition 1 and 2 showed better source memory for Condition 1, representing source memory for unexpected sources, than Condition 2, representing source memory for expected sources. Therefore, we found an inconsistency effect in source memory as predicted by the AEH. Experiment 2 supported data analysis of Experiment 1 with Model 5d assuming source-memory differences instead of data analysis with Model 5a assuming differences in guessing biases.

3.2.3 Experiment 3

In Experiment 3, we used different materials to replicate findings of Experiment 1. Sources were "house of a family with children" and "house of a family without children." Items were child-expected objects that were very expected for a family with children and very unexpected for a family without children. Additionally, we added a control condition with equally expected items (very expected for both families) to test predictions of the AEH more closely. If both sources are expected for an item, no source-memory advantage for one of the sources should exist.

We used the 2HTSM for two sources for data analysis again. We found an inconsistency effect in source memory for child-expected items with better source memory for the unexpected source replicating findings of Experiment 1. Additionally, we found no source-memory difference between both expected sources for equally expected items.

3.2.4 Experiment 4

Besides predictions of the AEH we tested predictions of the TVA in Experiment 4. We used one expected and two unexpected sources influencing the ratio of expected and unexpected sources. Again we used material with high expectancy strength:

Sources were "kitchen," "bathroom," and "nursery." Objects were very expected for a kitchen and very unexpected for a bathroom and a nursery (expected-kitchen items), very expected for a bathroom and very unexpected for a kitchen and a nursery (expected-bathroom items), and very expected for a nursery and very unexpected for a kitchen and a bathroom (expected-nursery items). Data analysis using the 2HTSM for three sources (Riefer et al., 1994; Keefe et al., 2002) showed no memory differences between expected and unexpected sources as predicted. Therefore, AEH and TVA were supported.

3.2.5 Experiment 5

In contrast to Experiment 4, we used two expected and one unexpected source in Experiment 5. Sources were "balcony," "garden," and "bathroom" and items were very expected for a balcony and a garden, and very unexpected for a bathroom. We applied the 2HTSM for three sources for data analysis again. We found an inconsistency effect in source memory with better source memory for the unexpected source supporting predictions of the AEH and TVA.

3.3 Discussion

By using material with high expectancy strength, we supported predictions of the AEH and TVA in five source-monitoring experiments. For experimental setups using one expected and one unexpected source (Experiment 1, 2 and 3), the AEH proposes better source memory for unexpected sources, and the TVA denies additional influences of attention on source-memory performance. In conclusion, inconsistency effects in source memory with better source memory for unexpected sources should exist. Using model-based approaches (multinomial modeling with the 2HTSM; Bayen et al., 1996) as well as a design-based approach (Küppers & Bayen, 2012) for data analysis, we supported predictions of the AEH and TVA revealing inconsistency effects in source memory.

Using a source-monitoring paradigm with three instead of two sources, we examined predictions of the AEH and TVA in more detail. Using one expected and two unexpected sources, the AEH proposes better source memory for unexpected sources, whereas the TVA proposes better source memory for the expected source. Taken together, no inconsistency effects in source memory but equal source memory for expected and unexpected sources should exist. Applying the 2HTSM for three sources (Riefer et al., 1994), we found no inconsistency effects and no source-memory differences in Experiment 4 supporting predictions of AEH and TVA.

Using one unexpected and two expected sources in Experiment 5, AEH and TVA propose better source memory for the unexpected source, revealing inconsistency effects in source memory. In fact, data analysis with the 2HTSM for three sources showed an inconsistency effect with better source memory for the unexpected source supporting AEH and TVA.

Summarizing our results, attention seems to influence source-memory performance. Using the same number of expected and unexpected sources, inconsistency effects with better source memory for unexpected sources occur. Additionally, the ratio of expected and unexpected sources seems to influence the occurrence of inconsistency effects. Using more expected than unexpected sources, inconsistency effects occur due to predictions of AEH and TVA. Using more unexpected than expected sources, no source memory-differences between expected and unexpected sources occur because of additional attention drawn to unexpected information (AEH) and additional attention drawn to expected information (TVA).

4 Guessing Strategies

Besides source-memory effects, investigation of guessing strategies can be important too. To judge trustworthiness and plausibility of responses in source-monitoring tasks (e.g., court testimony), systematical analyses of guessing biases are needed. It can be decisive if guessing is influenced due to schemas (Bayen et al., 2000) or due to metacognitive beliefs (Batchelder & Batchelder, 2008) resulting in guessing biases towards the expected source, in guessing biases towards the unexpected source or in guessing on chance level.

4.1 Theoretical and Empirical Background

The use of stereotypes, schemas, and general knowledge is not only limited towards memory processes but also takes place when persons need to guess answers at source-monitoring tasks (Bayen et al., 2000). When we cannot remember the correct source of information, we might guess the most plausible answer option: We might suppose that the statement "Take this medicine" was made by our doctor, whereas the statement "The report must be finished until tomorrow" was made by our boss.

4.1.1 Schema-Based Guessing

Schema-based guessing was proposed by Bayen et al. (2000), Klauer et al. (2002), and Wegener (2000). When a schema or stereotype is activated at encoding (like our doctor telling some statements), a schema-consistent guessing bias towards the expected source occurs. In conclusion, persons orient on existing schemas and general knowledge when not remembering the correct source of information.

Bayen et al. (2000) and Klauer et al. (2002) supported the schema-based guessing hypothesis using different types of materials (room schemas and objects vs. person schemas and statements). When participants could not remember the source, they guessed the expected source resulting in a schema-consistent guessing bias.

4.1.2 Compensatory Guessing

Instead of schema-based guessing always resulting in a schema-consistent guessing bias, Batchelder and Batchelder (2008), Ehrenberg and Klauer (2005), and Küppers and Bayen (2012) proposed a metacognitive guessing strategy influenced by persons' impressions about their own memory. They called it *compensatory guessing* (Ehrenberg & Klauer, 2005; Küppers & Bayen, 2012) because guessing bias compensates for the poor memory of one category. If one item category or source category can be remembered better than the other ones, guessing will occur towards the less remembered category.

Riefer et al. (1994) and Meiser et al. (2007) supported the compensatory-guessing hypothesis in source-monitoring experiments. They enhanced memory for one category without using schemas or stereotypes (e.g., long presentation time vs. short presentation time). Investigation of guessing biases showed guessing towards the less remembered category and supported the compensatory-guessing hypothesis.

4.1.3 Contingency-Based Guessing

Additionally, Batchelder and Batchelder (2008) and Wegener (2000) proposed another metacognitive guessing hypothesis called *contingency-based guessing*. In schema-based source-monitoring tasks, contingencies often describe the ratio of expected and unexpected item-source pairings. For example, a 50:50 contingency exists if half of the items were presented with the expected source and the other half with the unexpected source.

The contingency-based guessing hypothesis states that participants adjust their source guessing to the perceived ratio of expected and unexpected item-source pairings. A schema-consistent contingency (e.g., 75% expected and 25% unexpected) should lead to schema-consistent guessing, a schema-inconsistent contingency (e.g., 25% expected and 75 unexpected) should lead to schema-inconsistent guessing, and a schema-neutral contingency (50% expected and 50% unexpected) should lead to guessing on chance level. Guessing biases reflecting the contingency used in the respective experiment were found by Bayen and Kuhlmann (2011), Ehrenberg and Klauer (2005, Experiment 2), and Kuhlmann et al. (2012) supporting the contingency-based guessing hypothesis.

4.2 Overview of the Studies

We tested predictions of the schema-based guessing hypothesis, compensatory-guessing hypothesis and contingency-based guessing hypothesis in four experiments. The schema-based guessing hypothesis always predicts a schema-consistent guessing bias, while the compensatory-guessing hypothesis predicts guessing compensating for the poor memory of one category, and the contingency-based guessing hypothesis predicts guessing orienting on perceived contingencies.

In Experiment 1 and 3, we found an inconsistency effect in source memory with better source memory for unexpected sources using the same number of schema-consistent and schema-inconsistent item-source pairings (50:50 contingency). The schema-based guessing hypothesis and the compensatory-guessing hypothesis predict a schema-consistent guessing bias. In contrast, the contingency-based guessing hypothesis predicts guessing on chance level reflecting the 50:50 contingency used in the experiments.

In Experiment 6 and 7, we manipulated source memory towards better source memory for the expected source to test predictions of the schema-based and compensatory-guessing hypothesis. The schema-based guessing hypothesis predicts a schema-consistent guessing bias again, whereas the compensatory-guessing hypothesis predicts a schema-inconsistent guessing bias compensating for better source memory for expected sources. We combined a design-based approach using two sources in Experiment 6 with a model-based approach using three sources in Experiment 7.

4.2.1 Experiment 1

We used Experiment 1 not only to investigate inconsistency effects but also to measure guessing biases. Using the 2HTSM (Bayen et al., 1996) to separate source memory, item memory, and guessing biases, source guessing could be investigated. We found schema-consistent guessing towards the expected source supporting the schema-based guessing hypothesis. Additionally, the compensatory-guessing hypothesis was supported because an inconsistency effect in source memory with better source memory for unexpected sources as well as a compensatory schema-consistent guessing bias existed. In contrast, participants' contingency perception reflected the true 50:50 contingency. Therefore, the contingency-based guessing hypothesis predicted guessing on chance level, and could not be supported.

4.2.2 Experiment 3

Results of Experiment 1 were replicated by Experiment 3. We found an inconsistency effect in source memory with better memory for unexpected sources, as well as schema-consistent guessing biases supporting the schema-based and compensatory-guessing hypothesis. Contingency perception reflected the true 50:50 contingency again and the contingency-based guessing hypothesis could not be supported.

Experiment 3 included an additional control condition with equally expected items. All guessing hypotheses predict guessing on chance level for this item type: Because both sources are expected for equally expected items, the schema-based guessing hypothesis predicts guessing on chance level; because no memory difference between both expected sources exist, the compensatory-guessing hypothesis predicts guessing on chance level due to the fact that no memory advantage for one source needs to be compensated; because of the 50:50 contingency, even the contingency-based guessing hypothesis predicts guessing on chance level. In fact, we found no memory differences and guessing on chance level for equally expected items supporting all guessing hypotheses.

4.2.3 Experiment 6

As the contingency-based guessing hypothesis was not supported in Experiment 1 and 3, we concentrated on investigating schema-based guessing and compensatory guessing more closely. We manipulated source memory towards better source memory for the expected source via longer presentation time for expected sources to test predictions of the schema-based and compensatory-guessing hypothesis.

Using materials of Experiment 1 and a design-based approach, we compared two different conditions: One condition included an "I don´t know" response option (e.g., Dodson, 2007; Dodson et al., 2008) for source identification. Participants could choose the "I don´t know" response option instead of guessing a source, when they did not remember the correct source. In this condition, source guessing should be low. The second condition did not include an "I don´t know" response option. Participants had to guess a source, when they did not remember the correct source. In this condition, source guessing should be high.

Comparing both conditions, we examined increases in "expected source" responses and "unexpected source" responses for the condition without "I don´t know" response option. Whether greater increases in the "expected source" response option would show schema-consistent guessing supporting the schema-based guessing hypothesis, greater increases in the "unexpected source" response option would show schema-inconsistent guessing supporting the compensatory-guessing hypothesis. Equal increases in both response options would reflect guessing on chance level, and neither support the schema-based nor the compensatory-guessing hypothesis.

Analyzing source-memory performance, we found better source memory for expected sources than unexpected sources. Comparing both conditions, we found significant greater increases in the "expected source" responses as in the "unexpected source" responses revealing schema-consistent guessing. In sum, we could not support the compensatory-guessing hypothesis predicting schema-inconsistent guessing biases. Instead, schema-consistent guessing supporting the schema-based guessing hypothesis occurred.

4.2.4 Experiment 7

Because the design-based approach of Experiment 6 cannot guarantee that participants actually choose the "I don´t know" response option when not remembering the correct source and therefore reveals no pure guessing measure, we added Experiment 7 using a model-based data analysis. We used materials of Experiment 4 with "kitchen," "bathroom," and "nursery" as sources and expected-kitchen, expected-bathroom, and expected-nursery objects as items. We manipulated again source-memory performance towards better source memory for the expected source than the unexpected sources using three instead of two sources.

In fact, we found better source memory for the expected source as well as schema-consistent instead of schema-inconsistent guessing biases. In line with Experiment 6, the schema-based guessing hypothesis was supported, while the compensatory-guessing hypothesis predicting schema-inconsistent guessing was not supported.

4.3 Discussion

We investigated source guessing in four source-monitoring experiments by using material with high expectancy strength. In Experiment 1 and 3, we found an inconsistency effect in source memory with better source memory for unexpected sources, as well as a schema-consistent guessing bias. Results supported the schema-based guessing hypothesis and the compensatory-guessing hypothesis. Because of memory advantages for unexpected sources, the schema-consistent guessing bias compensates the poor memory for expected sources. Additionally, participants' contingency perception reflected the true 50:50 contingency used in Experiment 1 and 3. In conclusion, the contingency-based guessing hypothesis predicting guessing on chance level could not be supported because schema-consistent guessing instead of guessing on chance level existed.

In a next step, we investigated schema-based and compensatory guessing in more detail. In Experiment 6 and 7, we manipulated source memory towards better source memory for the expected source. In conclusion, the schema-based guessing hypothesis predicts schema-consistent guessing whereas the compensatory-guessing hypothesis predicts schema-inconsistent guessing compensating for poor memory for unexpected sources. The design-based approach of Experiment 6 as well as the model-based approach of Experiment 7 revealed schema-consistent rather than schema-inconsistent guessing biases and supported the schema-based guessing hypothesis instead of the compensatory-guessing hypothesis.

Summarizing our results, schemas and stereotypes seem to influence guessing biases seriously. Using material with high expectancy strength in four source-monitoring experiments, only the schema-based guessing hypothesis was supported in all experiments. Neither the compensatory-guessing hypothesis could explain results of Experiment 6 and 7 nor could the contingency-based guessing hypothesis explain results of Experiment 1 and 3.

5 General Discussion

We investigated source-memory effects as well as guessing strategies in seven source-monitoring experiments using material with high expectancy strength. Concerning source-memory effects, we supported predictions of two hypotheses concerning influences of attention towards source-memory performance. The AEH proposes better source memory for unexpected sources because of attention drawn to unexpected information whereas the TVA proposes better source memory for sources with special features because of attention drawn to these sources (e.g., better source memory for the expected source using one expected and two unexpected sources).

If no source with special feature exists, as in Experiment 1, 2, and 3 using one expected and one unexpected source, an inconsistency effect in source memory with better source memory for unexpected sources occurs as predicted by the AEH. Using different ratios of expected and unexpected sources (Experiment 4 and 5), the occurrence of inconsistency effects in source memory depends on the actual ratio of expected and unexpected sources. In Experiment 4, we used more unexpected than expected sources revealing no inconsistency effect with equal source memory for expected and unexpected sources as predicted by the AEH due to additional attention drawn to unexpected information and the TVA due to additional attention drawn to expected information. In contrast in Experiment 5, we used more expected than unexpected sources revealing an inconsistency effect with better source memory for unexpected sources as predicted by AEH and TVA because of additional attention drawn to unexpected information.

In conclusion, inconsistency effects in source memory do not occur in general. The ratio of expected and unexpected sources is decisive for such memory effects. Using the same ratio of expected and unexpected sources as well as more expected than unexpected sources, inconsistency effects occur, whereas using more unexpected than expected sources, no inconsistency effects but equal source memory for expected and unexpected sources occur. While better source memory for unexpected sources occurred under specific conditions, better source memory for expected sources did not occur without additional manipulation (e.g., longer presentation time for expected sources in Experiment 6). Further research may examine influences of different ratios of expected and unexpected sources more closely. Ratios could be manipulated towards two expected and four unexpected sources or one expected and five unexpected sources investigating source-memory performance for expected sources. Maybe additional attention drawn to the expected sources (as predicted by the TVA) exceeds additional attention drawn to many unexpected sources (as predicted by the AEH) revealing better source memory for expected than unexpected sources.

Additionally, we investigated guessing strategies. We tested predictions of the schema-based guessing hypothesis proposing schema-consistent guessing, the compensatory-guessing hypothesis proposing guessing compensating for poor memory of one source category, and the contingency-based guessing hypothesis proposing guessing orienting on perceived contingencies.

Results of four source-monitoring experiments supported the schema-based guessing hypothesis and refute both compensatory-guessing hypothesis and contingency-based guessing hypothesis revealing schema-consistent guessing biases. The contingency-based guessing hypothesis could not explain schema-consistent guessing in Experiment 1 and 3 not reflecting the perceived 50:50 contingency. The compensatory-guessing hypothesis could not explain schema-consistent guessing in Experiment 6 and 7 not compensating for better source memory for expected sources.

Riefer et al. (1994) and Meiser et al. (2007) found compensatory guessing using no schemas as well as Bayen and Kuhlmann (2011), Ehrenberg and Klauer (2005, Experiment 2), and Kuhlmann et al. (2012) found contingency-based guessing using material with low expectancy strength. Therefore, the existence of schemas and strength of schema activation seem to influence guessing strategies:

If no schema is available, compensatory guessing (Riefer et al., 1994; Meiser et al., 2007) and contingency-based guessing (Buchner, Erdfelder, & Vaterrodt-Plünnecke, 1995) occurs. In this case, metacognitive guessing strategies as compensating for memory differences or orienting on perceived contingencies are plausible. Further research may examine whether compensatory guessing or contingency-based guessing occur when both guessing strategies compete and no schema is available.

If schemas are available, guessing strategies change. Using low expectancy strength indicated by overlapping and not distinct sources as well as items that are just somewhat unexpected and not very unexpected, schemas might be not activated that much. In this case, contingency-based guessing occurs if a contingency can be perceived, and schema-based guessing occurs if no contingency can be perceived as predicted by the probability matching account (Spaniol & Bayen, 2002). Therefore, perceived contingencies seem to provide more evidence than the low activated schema, and contingency-based guessing outdoes schema-based guessing if contingencies are available (Bayen & Kuhlmann, 2011; Kuhlmann et al., 2012; Spaniol & Bayen, 2002). Further research may examine if compensatory guessing occurs using material with low expectancy strength. In a next step, the compensatory-guessing hypothesis and the contingency-based guessing hypothesis could be tested against each other when both guessing strategies compete.

If schemas are available and high expectancy strength is used indicated by distinct sources as well as items that are very unexpected instead of just somewhat unexpected, schemas are strongly activated. In this case, schema-based guessing occurs instead of compensatory guessing or contingency-based guessing because the activated schema provides most evidence. In everyday life, schema-based guessing is a nearly perfect strategy because unexpected information occurs very rarely and schema-consistent guessing mostly leads to correct responses. In conclusion, schema-based guessing is the most adaptive strategy when schemas are available and expectancy strength is high.

Combining results concerning source-memory effects and guessing strategies, we found better source memory for unexpected sources or equal source memory for expected and unexpected sources as well as schema-consistent guessing towards the expected source. "Unexpected source" responses were mainly made due to correct memory, whereas "expected source" responses were made due to memory and in large part due to guessing. In conclusion, "unexpected" responses were less influenced due to guessing than "expected" responses. For court testimony, these results suggest that unexpected descriptions of a crime scene or criminal mainly represent memory, whereas expected descriptions represent memory and in large part guessing. Therefore, unexpected testimonies are more trustworthy and useful than expected testimonies.

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Article B:

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Inconsistency Effects in Source Memory and Compensatory Schema-Consistent Guessing

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Abstract

The attention-elaboration hypothesis of memory for schematically unexpected information (Brewer & Treyens, 1981) predicts better source memory for unexpected than expected sources. In three source-monitoring experiments, the authors tested the occurrence of an inconsistency effect in source memory. Participants were presented with items that were schematically either very expected or very unexpected for their source. Combining multinomial modeling (Experiments 1 and 3) with a design-based approach (Experiment 2), the authors separated source memory, item memory, and guessing bias. Results support an inconsistency effect in source memory accompanied by a compensatory schema-consistent guessing bias when expectancy strength is high indicated by items that are very expected or very unexpected for their source.

Keywords: inconsistency effect, schemas, source monitoring, response bias, multinomial modeling

Inconsistency Effects in Source Memory and Compensatory Schema-Consistent Guessing

Source monitoring refers to "the set of processes involved in making attributions about the origins of memories, knowledge, and beliefs" (Johnson, Hashtroudi, & Lindsay, 1993, p. 3). For example, we may have to remember where we put our keys. We may not be able to remember where we put the keys the last time we used them. In this case, we may begin the search at the most expected place for keys, that is the key box. Thus, if we do not remember where we put our keys, we use prior knowledge such as schemas, stereotypes, beliefs, and plausibility (Johnson, et al., 1993) and may thus guess the location or source of the keys (Bayen, Nakamura, Dupuis, & Yang, 2000).

Alternatively, we may actually remember where we put our keys the last time we used them. For example, we came home with many shopping bags. We gave our keys to our child so that she could open the door. When we try to remember where we put our keys, we might remember that we gave them to our child and may ask her where our keys are.

There are two main findings in the literature on effects of schemas on item memory. Some studies showed a consistency effect with better memory for schema-consistent items measured via overall item recall and amount of clustering as well as hit rates in forced-choice tasks (e.g., Cissé & Heth, 1989; C. E. Cohen, 1981). Other studies showed an inconsistency effect with better memory for inconsistent items measured with free-recall and recognition-memory tasks (Mäntylä & Bäckman, 1992; Pezdek, Whetstone, Reynolds, Askari, & Dougherty, 1989; Smith & Graesser, 1981). Two meta-analyses of (in)consistency effects in social psychology (Rojahn & Pettigrew, 1992; Stangor & McMillan, 1992) pointed out that the measures used in the examined studies are responsible for these contradictory findings. Measures corrected for response bias (such as *d'*) revealed better memory for inconsistent information as well as schema-consistent response bias; measures confounding memory and response bias (such as hit rate, false alarm rate, and forced-choice measures) revealed better performance for consistent information. It, thus, appears that there is better memory for schema-inconsistent information, accompanied by a schema-consistent response bias. The *inconsistency effect* (Ehrenberg & Klauer, 2005) describes this phenomenon of better memory for schema-inconsistent information. The effect is sometimes also called *typicality effect* (Erdfelder & Bredenkamp, 1998) or *incongruity effect* (Bell, Buchner, Kroneisen, & Giang, in press).

As an explanation for inconsistency effects, the *attention-elaboration hypothesis* (Brewer & Treyens, 1981; Friedman, 1979; Loftus & Mackworth, 1978) states that schema-inconsistent information attracts more attention than schema-consistent information and is, therefore, processed more deeply and elaborately. As a result, schema-inconsistent information should be easier to retrieve than schema-consistent information. Empirical evidence clearly supports the attention-elaboration hypothesis for item memory (e.g., Erdfelder & Bredenkamp, 1998; Mäntylä and Bäckman, 1992; Vakil, Sharot, Markowitz, Aberbruch, & Groswasser, 2003).

Bayen et al. (2000) as well as Ehrenberg and Klauer (2005) extended the attention-elaboration hypothesis to source-monitoring tasks proposing better source memory for unexpected than expected sources. In typical laboratory source-monitoring tasks, participants are presented with items from two or more sources. In a later test, they are asked whether each given item originated from Source A, from Source B, or is new. Responses are influenced by item memory, source memory, and different types of guessing bias (cf., Murnane & Bayen, 1996). Therefore, to test the occurrence of inconsistency effects in source memory, independent measures of item memory, source memory, and guessing biases are needed. Many studies used a formal model to separate item memory, source memory, and guessing (e.g., Bayen & Kuhlmann, 2011; Bayen et al., 2000; Dodson, Darragh, & Williams, 2008; Ehrenberg & Klauer, 2005; Gawronski, Ehrenberg, Banse, Zukova, & Klauer, 2003;

Kuhlmann, Vaterrodt, & Bayen, 2012), namely the two-high-threshold multinomial model of source monitoring (Bayen, Murnane, & Erdfelder, 1996; see Figure A1 and description in Appendix A). They reported mixed results concerning inconsistency effects in source memory.

Using items that originated from either an expected or a somewhat unexpected source, Bayen and Kuhlmann (2011), Dodson et al. (2008), and Kuhlmann et al. (2012) did not find an inconsistency effect in source memory, but equal memory for both sources. With a similar paradigm, Bayen et al. (2000; Experiment 1) found a non-significant advantage for the unexpected source. Ehrenberg and Klauer (2005) found an inconsistency effect only in the condition with greatest task difficulty using load and a long retention interval. This result is in line with those of Stangor and McMillan (1992) who also found difficult tasks bolstering inconsistency effects. Gawronski et al. (2003) found an inconsistency effect in source memory for strong stereotypic associations only, and not for weak stereotypic associations. In sum, no definite conclusion concerning inconsistency effects in source memory can be drawn at this point.

A possible reason for the lack of inconsistency effects in the studies by Bayen and Kuhlmann (2011), Bayen et al. (2000), Dodson et al. (2008), Ehrenberg and Klauer (2005), and Kuhlmann et al. (2012) may be that the sources were only *somewhat* unexpected (such as a lawyer talking about medicine) and not very unexpected for the items. According to the attention-elaboration hypothesis, schema-inconsistent information attracts more attention and is processed more deeply than schema-consistent information. If information is only *somewhat* unexpected, however, it attracts less attention and is, therefore, less well remembered. Gawronski et al. (2003) and Stangor and McMillan (1992) supported this connection between expectancy strength and the occurrence of inconsistency effects. As reported by Gawronski et al., individuals with strong stereotypical beliefs had better memory for inconsistent stereotypes, whereas individuals with weaker stereotypical beliefs showed no difference in memory. In line, Stangor and McMillan found in a meta-analysis that a low level of expectancy (i.e., items only moderately related to a schema) may decrease the inconsistency effect in item memory. We expected that an inconsistent source will be well attended to if expectancy strength is high, that is, items are *very* unexpected for their source and will, therefore, be better remembered than a consistent one.

The studies by Bayen and Kuhlmann (2011), Ehrenberg and Klauer (2005), and Kuhlmann et al. (2012) used person schemas. Although participants may have schemas of skinheads and social workers (Ehrenberg & Klauer, 2005), or of lawyers and doctors (Bayen & Kuhlmann, 2011), they know that humans are very complex and will never fit in one particular schema only. For example, although someone may be a skinhead representing many bad attitudes, he may also love his mother or care for a pet representing good attitudes. Therefore, the inconsistent statements may not be seen as very unexpected for the person. In fact, the norming studies regarding person schemas by Bayen et al. (2000, Experiment 2) and Kuhlmann et al. showed that the items used in their source-monitoring experiments were only somewhat unexpected, and not very unexpected for one source. In their experiment using scenes, Bayen et al. (2000) also used items that were, according to a norming study, only somewhat unexpected for one of the sources. That is, there was some overlap between the used scenes bathroom and bedroom. For example, clothes, books, and a clock are expected in a bedroom, but may also appear in a bathroom; medicine, towels, and deodorant are expected in a bathroom, but may also occur in a bedroom. In sum, if sources are only somewhat unexpected, they might not attract that much attention and undergo no deeper elaboration than expected sources. Therefore, to test whether there are inconsistency effects in source memory, we increased expectancy strength by using very expected and very unexpected items as well as sources with very distinct schemas. We decided to use scene schemas (Bayen et al. 2000, Experiment1) instead of person schemas (Bayen & Kuhlmann, 2011; Bayen et al., 2000, Experiment 2; Ehrenberg & Klauer, 2005; Kuhlmann et al., 2012), because scenes are not as complex as human personality.

Besides the inconsistency effect in source memory, Ehrenberg and Klauer (2005) as well as Gawronski et al. (2003) found a guessing bias towards the expected source, corresponding to the schema-consistent guessing bias reported by Stangor and McMillan (1992) for item memory. Bayen et al. (2000, Experiment 1) also found a schema-consistent guessing bias, although the memory advantage for expected sources was small and not significant. The guessing bias seemed to compensate the better source memory for unexpected sources.

Such compensatory guessing bias has been proposed by Batchelder and Batchelder (2008). According to these authors, the *cause heuristic* reflects a guessing bias influenced by participants' impressions about their own memory. If an item category or a source category can be remembered better, guessing will occur towards the less remembered category. We will refer to this type of guessing bias as *compensatory guessing*, because it compensates for the poor memory for this category. The compensatory-guessing hypothesis was supported by Riefer, Hu, and Batchelder (1994) in two source-monitoring experiments using the generation effect and the picture superiority effect. In both experiments, a guessing bias towards the less remembered source occurred. That is, the experiment using the generation effect showed a guessing bias towards "other person generated the item" rather than "I generated the item." The experiment using the picture superiority effect showed a guessing bias towards "word" instead of "picture." In line, Meiser, Sattler, and von Hecker (2007) also found a compensatory guessing bias. They improved memory by presenting some items more often or longer than others. Guessing bias occurred in the opposite direction towards "rarely shown" and "short presentation time."

Additionally, Batchelder and Batchelder (2008) proposed a second heuristic, the *base rate heuristic*. If a base rate (e.g., the contingency of items presented by the expected source and items presented by the unexpected source) is recognized by participants, they will use this information as a heuristic to adjust their guessing bias towards this base rate. Such *contingency-based guessing* was found in a large body of research (e.g., Bayen & Kuhlmann, 2011; Ehrenberg & Klauer, 2005; Klauer & Meiser, 2000; Klauer & Wegener, 1998; Kuhlmann et al., 2012; Spaniol & Bayen, 2002).

Ehrenberg and Klauer (2005) used a zero contingency, that is, the same number of items presented by the expected and the unexpected source in a study in which they found better memory for the expected source. They found a schema-consistent guessing bias representing compensatory guessing instead of contingency-based guessing at chance level. It seems that participants use contingency-based guessing if they realize the contingency and no memory differences exist (Bayen & Kuhlmann, 2011; Ehrenberg & Klauer, 2005; Klauer & Meiser, 2000; Klauer & Wegener, 1998; Kuhlmann et al., 2012; Spaniol & Bayen, 2002). If, however, memory differences such as better memory for the expected source exist, compensatory guessing instead of contingency-based guessing seems to occur (Ehrenberg & Klauer, 2005; Gawronski et al., 2003).

To test whether inconsistency effects occur in source-monitoring tasks with high expectancy strength, we conducted three experiments. The experiments had two objectives. The first objective was to test the attention-elaboration hypothesis which predicts an inconsistency effect in source memory. To this end, we used items that were very expected and very unexpected for their sources, and sources with very distinct scene schemas.

Our second objective was to examine guessing bias. We predicted a compensatory guessing bias favoring the expected source as shown by Ehrenberg and Klauer (2005) and Gawronski et al. (2003). In addition, we measured participants' contingency perception to test whether participants recognized the zero contingency between items and sources or guessed in a schema-consistent manner because of the perception of a consistent contingency.

In Experiment 1, expectancy strength was high, and we used multinomial modeling to independently measure item memory, source memory, and guessing biases. The results of the modeling did not allow us to unequivocally separate source-memory and guessing effects. We, therefore, conducted Experiment 2 in which we used payoffs to manipulate guessing biases in a design-based approach to separate source memory and guessing. The results of Experiment 2 helped us interpret the modeling results from Experiment 1. We conducted Experiment 3 to replicate the findings of Experiment 1 with different materials and included a control condition to measure guessing bias when no memory differences existed.

Experiment 1

To yield high expectancy strength, we used objects that were very expected and very unexpected for kitchen and bathroom scenes. To separate source memory, item memory, and guessing, we used the two-high-threshold multinomial model of source monitoring (Bayen et al., 1996, see Figure A1) to analyze the data.

We expected better source memory for the expected source, that is an inconsistency effect in source memory. We also expected a schema-consistent guessing bias compensating for the memory difference.

Method

Participants. Forty-eight native speakers of German (24 female) participated. Age ranged between 18 and 30 years (M = 22.40 years). They received course credit or chocolate as compensation for their participation.

Design. We used a 2 x 2 factorial design with the independent variables object expectancy (expected-kitchen vs. expected-bathroom) and source (kitchen vs. bathroom). Both factors were manipulated within participants. Dependent variables were the parameters of the two-high-threshold multinomial model of source monitoring measuring item memory, source memory, and guessing biases (Bayen et al., 1996).

Materials. Ninety-six object labels were used as items. Half of the objects were very expected for a kitchen and very unexpected for a bathroom; the other half was very expected for a bathroom and very unexpected for a kitchen.

We conducted a norming study to determine the expectancy of items for kitchen and bathroom. The norming study followed the procedures used in the norming study by Bayen et al. (2000). We generated 876 German labels of objects that can be found in either a kitchen or a bathroom. Eighty-eight participants (half of them female) then rated the objects regarding their expectancy for a kitchen or a bathroom on a 5-point Likert scale (1 = *very unexpected*, 2 = *somewhat unexpected*, 3 = *neither unexpected nor expected*, 4 = *somewhat expected*, 5 = *very expected*). A random half of the participants rated object expectancy for a kitchen; the other half rated object expectancy for a bathroom. To select objects that are very expected for one and very unexpected for the other source, mean expectancy ratings were equal to or greater than 4.00 for the expected source, and equal to or less than 2.00 for the unexpected source. Expected-bathroom items had a mean expectancy rating for bathroom of 4.49 and for kitchen of 1.11. Expected-kitchen items had a rating for kitchen of 4.50 and for bathroom of 1.10. By contrast, the items used by Bayen et al. (2000, Experiment 1) had mean expectancy ratings for the unexpected source of 1.91 and 2.03. Thus, by using very unexpected items instead of somewhat unexpected items, we increased expectancy strength in the current study compared to prior studies.

Expected-bathroom and expected-kitchen items had equal frequency according to German frequency norms (University of Leipzig, 1998). There were no significant differences between expected-bathroom and expected-kitchen items in expected and unexpected ratings. The item pool included both very expected words with expectancy ratings of 4.77 to 5.00 and somewhat expected words with expectancy ratings of 4.07 to 4.25. To make sure that the same number of very expected and somewhat expected words were presented in the study list for all participants, we divided each item pool of one item type into two item lists with 24 items each. Both lists contained the same number of very expected and somewhat expected objects and did not differ significantly in expectancy ratings. At study, each list was presented to half of the participants. At test, all participants received all items.

Procedure. Each experimental session included one or two participants. Participants signed consent and then read instructions on the computer screen. They received no information about the upcoming source-monitoring test. At study, each object name was presented above a source for 4s. Object label and source were written in white capital letters on black background. Four items served as primacy buffer. Two of them were presented with the source “bathroom” and two with “kitchen.” After this primacy buffer, 48 items (24 expected-bathroom items, 24 expected-kitchen items) followed. Half of the items were presented with the expected source; the other half was presented with the unexpected source. The order of presentation was randomized by participant. Four item–list combinations (Bathroom Lists A and B crossed with Kitchen Lists A and B) were counterbalanced across participants.

Instructions for the source-monitoring test followed. In the test list, four practice items preceded the test items. Two of the practice items were new; two had appeared as primacy buffer in the study list, one with bathroom and one with kitchen. Test items were the 48 items shown in the study list and 48 new items (the bathroom and kitchen lists not been shown in study list) and were presented in white capital letters on black background, as before. Presentation order was again randomized by participant.

For each item, the question “Which room was this object presented with?” was asked. There were three response options: “bathroom,” “kitchen,” and “neither,” written in colored capital letters. Responses were given by hitting corresponding color-coded keys on the computer keyboard. “D” was marked with a green and “K” with a yellow sticker, these two keys indicated the sources bathroom and kitchen. Color assignment to the sources was counterbalanced across participants. The red space bar always indicated the answer “neither.”

After completing the memory test, participants made two contingency judgments in the form of frequency estimates. They were asked how many of the 24 expected-bathroom items were presented with bathroom in the study list, and how many of the expected-kitchen items were presented with kitchen. The order of these two questions was counterbalanced. A demographic questionnaire and a debriefing followed.

Results

We used the two-high-threshold multinomial model of source monitoring (Bayen et al., 1996; for a detailed description and figure of the model, see Appendix A) to separately measure item memory, source memory, and guessing bias. For clarity of presentation, we combined the data to items presented with the expected source and items presented with the unexpected source (as done by Spaniol and Bayen, 2002), instead of carrying out separate analyses for bathroom items and kitchen items. Response frequencies from Experiment 1 are shown in Table B1. We used the multiTree program (Moshagen, 2010) to carry out the analyses. We evaluated model fit using the asymptotically chi-square distributed goodness-of-fit statistic G^2 (Hu & Batchelder, 1994). A good model fit is indicated by G^2 values lower than the critical G^2. For the tests of overall model fit, we set alpha to .01, because power to even detect small deviations (w = .10, J. Cohen, 1988) using $\alpha = .05$ with n = 4608 (48 participants x 96 items) and df = 1 would have been greater than .99.[1]

Of the nine identifiable submodels of the 2HTSM (Bayen et al., 1996, Figure 4), we first tested the most restrictive Submodel 4 which assumes that there are neither item-memory nor source-memory differences, that is, no inconsistency effect. With $G^2(2) = 34.77$ (critical value of 9.21) the model did not fit the data. Next, we performed analyses with 5-parameter submodels. Submodels assuming a difference in item memory did not fit the data, Submodel 5b: $G^2(1) = 27.15$; Submodel 5c: $G^2(1) = 25.05$ (critical value of 6.63). By contrast, Submodel 5d assuming a difference in source memory showed good model fit, $G^2(1) = 2.51$ (critical value of 6.63).

However, Submodel 5a, assuming equal source memory, but a difference in guessing bias between recognized and unrecognized items always fits the data equally well as Submodel 5d, because they are equivalent models (Bayen et al., 1996). Thus, based on model-fitting of the data from this experiment, we cannot decide whether there is an inconsistency effect or not. Table C1 presents parameter estimates of Submodels 5d and 5a.

In line with our prediction of the inconsistency effect, we used Submodel 5d which allows for a difference in source memory. Source-memory and guessing parameters for this submodel are shown in Figure 1.

(Figure 1 about here)

There was a significant difference in source memory (d_E, d_U) with a higher parameter estimate for unexpected than expected sources, $\Delta G^2(1) = 32.26$. The probability g to guess the schema-consistent source was significantly above the chance level of .50, $\Delta G^2(1) = 116.71$. Contingency judgments showed quite good perceptions of item-source contingency (M = 12.67, SD = 3.45 for expected-bathroom items, and M = 12.40, SD = 2.68, for expected-kitchen items). Neither mean differed significantly from the correct value of 12; expected-bathroom: $t(47) = 1.34$, $p = .19$, $d = 0.19$; expected-kitchen: $t(47) = 1.02$, $p = .31$, $d = 0.15$.

Discussion

Submodel 5d of the multinomial model showed an inconsistency effect in source memory as well as compensatory guessing. A source-memory advantage for the unexpected source ($d_E < d_U$) and a schema-consistent guessing bias occurred ($g > .50$). Thus, the inconsistency effect in source memory as well as compensatory consistent guessing occurred with materials with high expectancy strength. The contingency judgments showed that participants were aware that the contingency was 50:50, that is, only half of the items had been presented with the expected source. Yet, schema-consistent guessing occurred. In conclusion, our hypothesis that compensatory guessing would occur and not contingency based guessing was supported.

Unfortunately, Submodel 5d (differences in source memory, no differences in guessing bias between recognized and unrecognized items) and Submodel 5a (differences in guessing bias between recognized and unrecognized items, but no differences in source memory) are equivalent; that is, they always fit the data equally well (Bayen et al., 1996). Based on Experiment 1, we can thus not unequivocally decide whether there is an inconsistency effect in source memory. We performed Experiment 2 to resolve this issue.

Experiment 2

Using the same materials as in Experiment 1, we conducted Experiment 2 to test if Submodel 5d is the right model to analyze the data from Experiment 1. In Experiment 2, instead of using a model-based approach towards separating item memory, source memory, and guessing biases, we used a design-based approach.

First, we wanted to measure source identification only, not item recognition. Therefore, we changed the experimental design such that we used the same items in the study list and the test list. Thus, the test list included no new items, and the test was a two-answer forced-choice test (2AFC) with the response options 1. the test item was shown with the "expected source," and 2. the test item was shown with the "unexpected source."

Second, we separated source memory and guessing bias by using a pay-off manipulation designed to influence guessing bias. Every correct answer gained money, whereas every incorrect answer cost money. We manipulated the cost of incorrect responses, while the amount of money earned for correct responses was the same across conditions. For participants in Condition 1, the response option "unexpected source" had high costs when chosen erroneously, and the response option "expected source" had low costs when chosen erroneously. For participants in Condition 2, costs were reversed; that is, the response option "expected source" had high costs when chosen erroneously, and the response option "unexpected source" had low costs when chosen erroneously. These pay-offs should lead to fewer responses with risk of high costs and more responses with risk of low costs (Maddox & Bohil, 2000). We presumed that responses given in favor of the option with high costs would be less influenced by guessing, because responses based on guessing would mostly be in the low-cost direction.

In Condition 1, a schema-consistent guessing bias should occur, because the response option "unexpected" had a risk of high costs. When there is such a strong schema-consistent guessing bias, we assume that "unexpected source" responses are mostly based on source memory and less on guessing. By contrast, in Condition 2, a schema-inconsistent guessing bias should occur, because the response option "expected source" had a risk of high costs. We assume that when there is a strong schema-inconsistent guessing bias, "expected source" responses will be mostly based on source memory and less on guessing.

We measured source memory as the proportion of correct responses (*d* derived from threshold theory) on the 2AFC source-monitoring test. As source memory for the unexpected source is measured in Condition 1, and source memory for the expected source is measured in Condition 2, a comparison of source-memory performance between Conditions 1 and 2 could reveal whether or not an inconsistency effect in source memory exists. Higher source memory in Condition 1 than in Condition 2 would show an inconsistency effect in source memory with better source memory for the unexpected source. Equal source memory in both conditions or higher source memory in Condition 2 than Condition 1 would refute an inconsistency effect in source memory.

If a comparison of source-memory performance between Conditions 1 and 2 shows better source memory for the unexpected source, then Submodel 5d of the multinomial model assuming differences in source memory across sources will be the appropriate model to analyze the data from Experiment 1, and the inconsistency effect found by analyzing the data from this experiment with this model would be supported. If, on the other hand, no better source memory for the unexpected source can be shown in Experiment 2, Submodel 5a assuming no differences in source memory for the expected versus unexpected source is the appropriate model to analyze the data from Experiment 1, and the inconsistency effect would not be supported.

Method

Participants. One-hundred students (half of them female) participated. Their age ranged between 18 and 35 years ($M = 22.02$ years). All participants were native speakers of German and none of them had participated in Experiment 1 nor the norming study. They received 2 Euro or course credit. In addition, every participant received the amount of money he or she earned according to his or her performance on the memory test (a maximum of 4 and a minimum of 0 Euro). They were randomly and equally assigned to the two pay-off conditions.

Design. The design was a 2 x 2 x 2 factorial. Object expectancy (expected-kitchen vs. expected-bathroom) and source (expected vs. unexpected) were manipulated within participants. The pay-offs were manipulated between participants (high costs for an incorrect "expected" answer vs. high costs for an incorrect "unexpected" answer). Dependent variables were D and g of the threshold theory.

Materials. We used the same 96 object labels as in Experiment 1.

Procedure. Each experimental session included between one and five participants. The study list was the same as the one used in Experiment 1. That is, 48 items (24 expected-bathroom items, 24 expected-kitchen items) were shown. Half of the items were presented with the expected source, the other with the unexpected source.

The procedure of the source-monitoring test differed from Experiment 1 in several points. Firstly, test items were old items from the study list only. Participants were informed before the test that there would be no new items on the test list. Secondly, there were two response options only. Participants were asked to decide whether an item had been presented by the expected or by the unexpected source. Thirdly, we added detailed instructions after the study list informing the participants that they could earn extra money depending on their performance on the memory test. Every correct answer would earn them 10 cents, whereas every incorrect answer would cost them money. In Condition 1, an incorrect “expected” answer cost them 10 cents, whereas an incorrect “unexpected” answer cost them 50 cents. In Condition 2, the costs were reversed. That is, an incorrect “unexpected” answer cost only 10 cents, whereas an incorrect “expected” answer cost 50 cents. Instructions extensively explained the pay-off rules, and participants trained with 16 practice items (eight of them had been shown in study list, eight were new). During training, pay-off instructions were repeated if a participant incorrectly chose the response option with high costs more than twice. As a consequence, participants got to the test list only if they understood the payoffs. The actual test items were the remaining 40 items from the study list.

Results

We used source-memory and guessing-bias measures derived from two-high threshold theory (Snodgrass & Corwin, 1988), because the multinomial model of source monitoring used to analyze the data from the other experiments is also based on two-high threshold theory.[2] For every decision, participants might have been able to remember the correct source

(source-memory parameter *d*). If they did not know the correct response, they had to guess a response (*g* = schema-consistent guessing; 1 – *g* = schema-inconsistent guessing). We calculated source-memory parameter *d* and guessing parameter *g* in the following manner (cf. Snodgrass & Corwin, 1988):

$$d = \text{correct source identification} - \text{incorrect source identification}$$

$$g = \text{incorrect source identification} / (1 - d).$$

Figure 2 shows source-memory parameter *d* and guessing parameter *g* for both pay-off conditions.

(Figure 2 about here)

The manipulation of guessing bias via higher costs for one of the response options should lead to strong guessing biases. In Condition 1, a schema-consistent guessing bias was expected, because the response option “unexpected” had high costs if an error was made. With a mean of .83 the guessing bias was significantly higher than the chance level of .50, $t(49) = 15.70$, $p < .001$, $d = 2.20$, and was thus in a schema-consistent direction. By contrast, in Condition 2, a schema-inconsistent guessing bias was expected, because the response option “expected” had high costs if an error was made. With a mean of .17 the guessing bias was significantly lower than chance, $t(49) = -16.52$, $p < .001$, $d = 2.36$, and was thus in the schema-inconsistent direction. Both guessing biases were equally strong, $t(98) = 0.16$, $p = .87$, $d = 0.00$. The pay-off manipulation was thus successful.

The analysis of source memory showed a significantly higher value of *d* in Condition 1 ($d = .39$) than in Condition 2 ($d = .31$), $t(98) = 1.78$, $p = .04$, $d = 0.33$. This meant better source memory for the unexpected than the expected source.

Discussion

We found an inconsistency effect in source memory. The occurrence of the inconsistency effect in this experiment supports the use of Submodel 5d of the multinomial model for analyses of Experiment 1. This model assumes differences in source memory. Summarizing the results of Experiments 1 and 2, the inconsistency effect occurs when expectancies are strong.

Experiment 3

Experiment 3 had two main objectives. First, we sought to replicate the findings of Experiment 1 with different materials. Second, we added a control condition with equally expected objects to verify that a memory advantage exists for unexpected sources only. If both sources are equally expected for an item, no source memory difference between sources is expected. Guessing biases for equally expected items should show guessing at chance level reflecting the 50:50 contingency used in this experiment.

To replicate the findings of Experiment 1 with different materials, we used child-related objects (e.g., cradle or potty) and the two sources “house of a family with children” and “house of a family without children.” In line with Experiment 1, we expected an inconsistency effect with better source memory for the unexpected source (child-related items presented with the house of a family without children) and compensatory consistent source guessing. The equally expected objects were expected for a house of a family with children as well as a house of a family without children (e.g., chair or table). For the equally expected objects, we expected no difference in source memory for both sources. In addition, we predicted guessing to be at chance level for this item type, because no compensation of differences in source memory was needed and both sources were equally expected.

Method

Participants. Forty-eight native speakers of German participated. All of them were female, and their age ranged between 19 and 26 years ($M = 21.06$ years). They had not participated in either of the other experiments, nor in norming studies. They received course credit or chocolate as compensation for their participation.

Design. As in Experiment1, we used a 2 x 2 factorial design with the independent variables object expectancy (child-expected vs. equally expected) and source (house of a family with children vs. house of a family without children). Both factors were manipulated within participants. Dependent variables were the parameter estimates of the multinomial model.

Materials. As in Experiment 1, we used 96 object labels as items. Two houses, one of a family with children and one of a family without children, served as sources. Forty-eight objects were very expected for a house of a family with children and very unexpected for a house of a family without children (child-expected items). The other 48 items were equally expected for both houses.

As for Experiment 1, we conducted a norming study to determine the expectancy of items for the two sources. We generated 408 German labels of objects that can be found in either a house of a family with children, or in both a house of a family with and a house of a family without children. Eighty-four native speakers of German (half of them female) rated the objects on the same 5-point Likert scale as in Experiment 1. There was a large difference between the expectancy ratings of men and women. Therefore, we only used the expectancy ratings of the women to choose the items used in this experiment and recruited females only to participate in the experiment. The 48 child-expected items had a mean expectancy rating for a house of a family with children of 4.29 and for a house of a family without children of 1.25. The equally expected items had the same mean expectancy rating of 4.24 for both houses. As in the materials used in Experiments 1 and 2, the schema-inconsistent expectancy rating was more extreme than the ones in Bayen et al. (2000, Experiment 1) with 1.25 instead of 1.91 and 2.03.

As in Experiment 1, we separated the item pool into two item lists per item type to make sure that the same number of very expected and somewhat expected words was presented in the study list for all participants. Both lists contained the same number of very expected and somewhat expected objects and did not differ significantly in expectancy ratings.

Procedure. The participants were tested individually. The procedure was the same as in Experiment 1. We only exchanged items (48 child-expected and 48 equally expected items) and sources ("house with children" and "house without children") and added a short description of the two sources.

Results

Table B2 in the Appendix shows response frequencies from Experiment 3. As in Experiment 1, we set alpha for the model-based analyses to .01, because with $\alpha = .05$, $n = 2304$, $df = 1$, and Cohen's $w = .10$, the statistical power would have been greater than .99. We performed the analyses separately for child-expected and equally expected items. Figure 3 shows source-memory and guessing parameters for child-expected and equally expected items.

(Figure 3 about here)

Table C1 presents the parameter estimates for all model parameters.

In line with Experiment 1, we used Submodel 5d with two different source-memory parameters for the expected source (house with children) and the unexpected source (house without children) to analyze the data for the child-expected items and yielded an acceptable model fit of $G^2(1) = 4.80$ (critical value of 6.63). The assumption of equality in source memory between expected and unexpected sources led to a significant decrease in model fit, $\Delta G^2(1) = 8.33$. Source memory was better for the unexpected source, that is, house without children ($d_E < d_U$). Guessing parameter g was significantly higher than chance, $\Delta G^2(1) = 22.66$ and thus showed schema-consistent guessing bias towards house with children.

For equally expected items, we predicted no difference in source memory. Therefore, we used Submodel 4 which assumes no source-memory differences. This model showed a good fit ($G^2(2) = 6.38$ with a critical value of 9.21) and thus implied no source-memory difference between items from the source house with children and the source house without children that were both expected for equally expected items. Also, the guessing probability *g* did not differ from chance, $\Delta G^2(1) = 1.78$.

The mean contingency judgment for child-expected items (12.94; *SD* = 3.35) did not differ significantly from the correct value of 12, $t(47) = 1.94$, $p = .06$, $d = 0.28$. The mean for equally expected items (10.63; *SD* = 3.38) was significantly lower than 12, $t(47) = -2.82$, $p = .007$, $d = 0.41$, showing more “house without children” judgments.

Discussion

The child-expected items showed an inconsistency effect in source memory. There was better source memory for the unexpected source as well as a compensatory guessing bias favoring the expected source. Although participants noticed the 50:50 contingency between items presented by the expected and unexpected source as revealed by the contingency judgments, schema-consistent guessing occurred supporting the compensatory guessing hypothesis.

As predicted, for equally expected items, there was no difference in source memory, and guessing was at chance. Although contingency judgments showed a bias towards “house without children,” we found no guessing bias in the source-monitoring task reflecting this contingency perception.

General Discussion

The first objective of our research was to examine whether or not there is an inconsistency effect in source memory. There are mixed results in the literature concerning this question (Bayen & Kuhlmann, 2011; Bayen et al., 2000; Ehrenberg & Klauer, 2005; Gawronski et al., 2003; Kuhlmann et al., 2012). The attention-elaboration hypothesis proposes a connection between expectancy strength and occurrence of inconsistency effects. High expectancy strength should lead to more attention towards schema-inconsistent information at encoding and, therefore, to better memory for schema-inconsistent information than for schema-consistent information. As studies revealing no inconsistency effects in source memory ((Bayen & Kuhlmann, 2011; Bayen et al., 2000; Ehrenberg & Klauer, 2005; Kuhlmann et al., 2012) used study material with low expectancy strength, we boosted expectancy strength by using very expected and unexpected items to investigate inconsistency effects in source memory.

In line with predictions of the attention-elaboration hypothesis, we found inconsistency effects in source memory with high expectancy strength in Experiments 1 and 2 and replicated this result in Experiment 3 with different materials. Additionally, in Experiment 3, we found no inconsistency effect for equally expected items, as predicted. Summarizing our current results and former results (Bayen & Kuhlmann, 2011; Bayen et al., 2000; Ehrenberg & Klauer, 2005; Gawronski et al., 2003; Kuhlmann et al., 2012), the inconsistency effect in source memory occurs with high expectancy strength, but not with low expectancy strength. Hence, expectancy strength appears to be a crucial variable for the occurrence of the inconsistency effect as predicted by the attention-elaboration hypothesis.

Our second objective was to examine guessing bias. Like Bayen et al. (2000, Experiment 1), Ehrenberg and Klauer (2005), and Gawronski et al. (2003), we found schema-consistent source guessing bias. This bias compensated for the poorer memory for consistent sources. We measured participants' contingency perception via contingency judgments to analyze whether participants recognized the zero contingency between consistent and inconsistent item-source pairings or guessed in the schema-consistent direction because of a contingency perception favoring the consistent source. The contingency judgments reflected the correct 50:50 contingency; thus, participants recognized that only half of the items had been presented with the consistent source, but guessed in the schema-consistent direction nonetheless. This result implicates that compensatory instead of contingency-based guessing occurred.

Summarizing the results, high expectancy strength leads to better memory for schema-inconsistent sources as well as compensatory schema-consistent guessing. In the context of eyewitness testimony, it is important that the identification of a criminal in a lineup be due to correct source memory for the crime scene, and not be confused with a mug shot of the same person as the source of memory for the face. Brown, Deffenbacher, and Sturgill (1977) found a connection between seeing a mug shot of a potential criminal and false identification at lineup. If a person has been seen on a mug shot, the probability of incorrectly identifying him or her at lineup increases because of source-memory errors. Eyewitnesses may think that they saw the person at the crime scene, but it was just on a mug shot. According to our research, an unexpected setting for judging mug shots may increase source memory for a person’s characteristics.

We used multinomial modeling to analyze the data from Experiments 1 and 3. With this approach, we could, however, not distinguish between two submodels of which one assumes differences in source memory and the other no differences in source memory, because both models always fit the data equally well (Batchelder & Riefer, 1990; Bayen et al., 1996). The design of Experiment 2 offers an alternative way of examining if source memory differences exist. By manipulating guessing biases via payoffs, we were able to show source-memory differences. Therefore, Experiment 2 supports the appropriateness of the multinomial submodel that assumes differences in source memory.

A limitation of the procedure used in Experiment 2 is that it does not allow us to measure guessing separately. This, however, was possible via the model-based approach taken to analyze the data from Experiments 1 and 3. By using a model-based approach in Experiments 1 and 3 and a design-based approach in Experiment 2, we combined the strength of both approaches. Results gained with both approaches converged to the conclusion that the inconsistency effect predicted by the attention-elaboration hypothesis can be found in source memory when expectancy strength is high.

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Footnotes

[1] Power analyses were computed with the G*POWER 3 program (Faul, Erdfelder, Lang, & Buchner, 2007).

[2] Analyses using SDT-based measures *d*' and *c* yielded the same pattern of results.

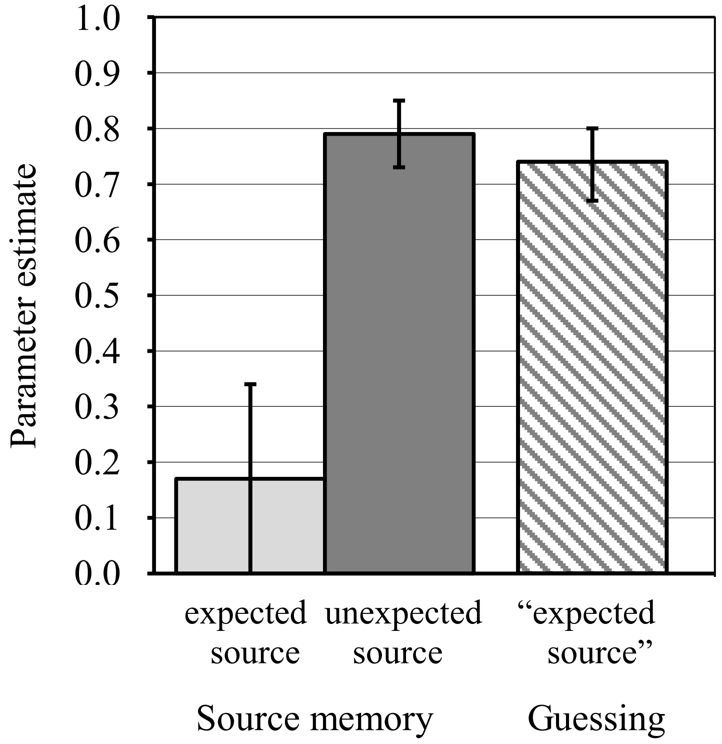

Figure 1. Source memory as a function of expectancy, and guessing in Experiment 1. Error bars indicate 95% confidence intervals.

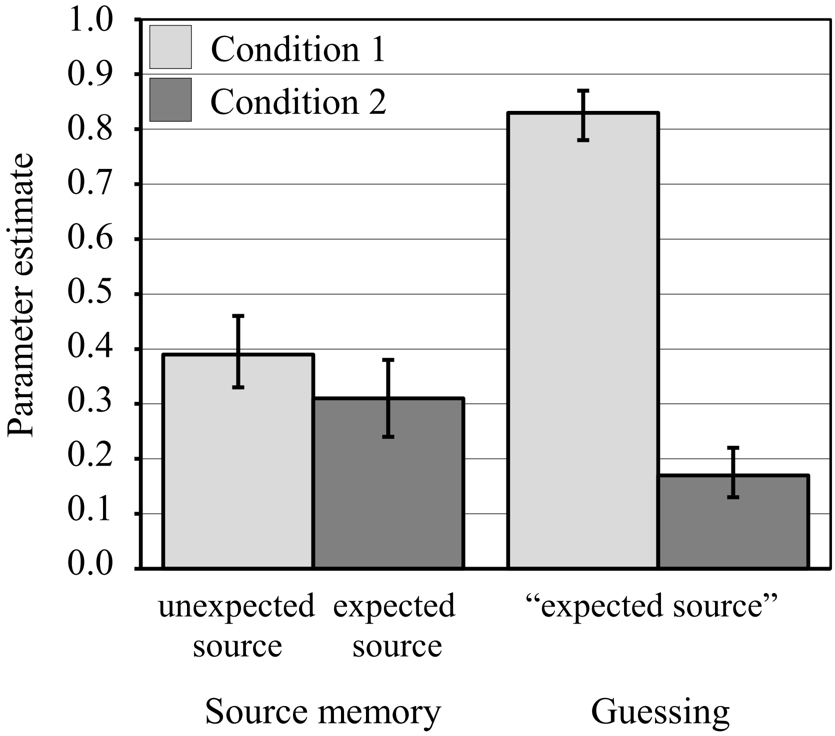

Figure 2. Source-memory and guessing parameters of the threshold theory for both conditions of Experiment 2. Condition 1 = pay-offs supporting the expected source. Condition 2 = payoffs supporting the unexpected source. Error bars indicate 95% confidence intervals.

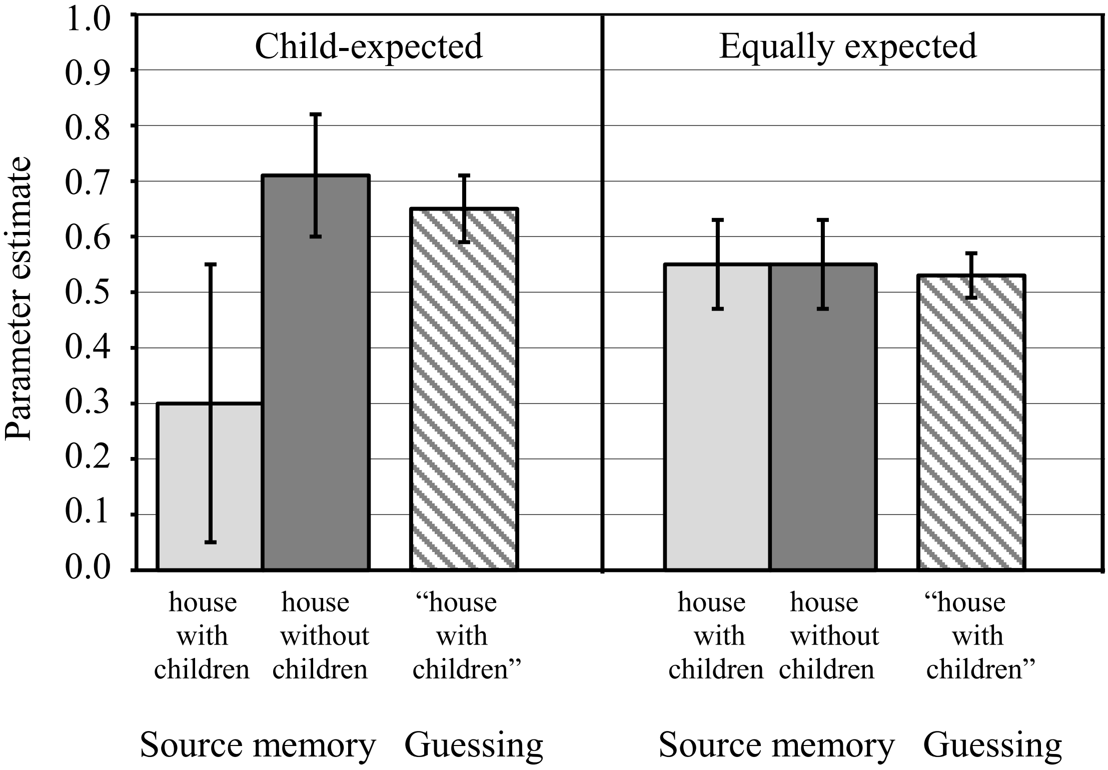

Figure 3. Source memory as a function of expectancy and source, and guessing "house with children" as a function of expectancy in Experiment 3. Error bars indicate 95% confidence intervals.

Appendix A: Two-high-threshold multinomial model of source monitoring

Figure A1 illustrates the 2HTSM (Bayen et al., 1996).

(Figure A1 about here)

In the source monitoring tasks used in Experiment 1 and 3, an object could be presented with the expected source (E), with the unexpected source (U) or it was new (N). For each object, there were three response options: “expected source,” “unexpected source,” or “new.” For equally expected items in Experiment 3 both sources were expected, and there was no unexpected source.

The first tree in Figure A1 represents objects that had been presented with the expected source in the study list. With probability D_E, participants recognize these objects correctly as old items (item memory). Participants may also remember that these objects have been presented with the expected source, with probability d_E (source memory). In this case, participants correctly answer “expected source.” With probability $1 - d_E$, participants cannot remember the source objects have been presented with. In this case, they have to guess a source. With probability *a,* they guess the expected source and answer correctly “expected source;” with probability $1 - a$, they guess the unexpected source and incorrectly answer “unexpected source.” When participants do not recognize the objects as old (with probability $1 - D_E$, they guess. With probability *b*, they guess that objects are old; with probability $1 - b$, they guess that objects are new and incorrectly answer “new.” If participants guess that objects are old, they have to guess the source as well. With probability *g,* they guess the expected source and answer correctly “expected source;” with probability $1 - g$, they guess the unexpected source and incorrectly answer “unexpected source.”

The second tree represents objects that have been presented with the unexpected source. Item recognition for these objects is represented by D_U and source memory by d_U. The third tree represents new objects. With probability D_N, participants know that these objects have not been presented in the study list and correctly answer "new." With the complementary probability $1 - D_N$, they do not know that objects are new and they guess "old" with probability b and guess "new" with probability $1 - b$.

The model shown in Figure A1 is not mathematically identifiable, because there are more free parameters (D_E, D_U, D_N, d_E, d_U, b, a, and g; eight parameters) than degrees of freedom in the data ($df = 6$). Identifiable submodels can be constructed via equality restrictions (e.g., $d_E = d_U$). All identifiable submodels are shown in Bayen et al. (1996, Figure 4).

Hypotheses can be tested via parameter restrictions (e.g., equal source memory for the expected and unexpected source, $d_E = d_U$; or guessing at chance level, $g = .50$). If the model fit indicated by goodness-of-fit index G^2 (which is asymptotically χ^2-distributed) significantly decreases due to this parameter restriction, the difference is significant.

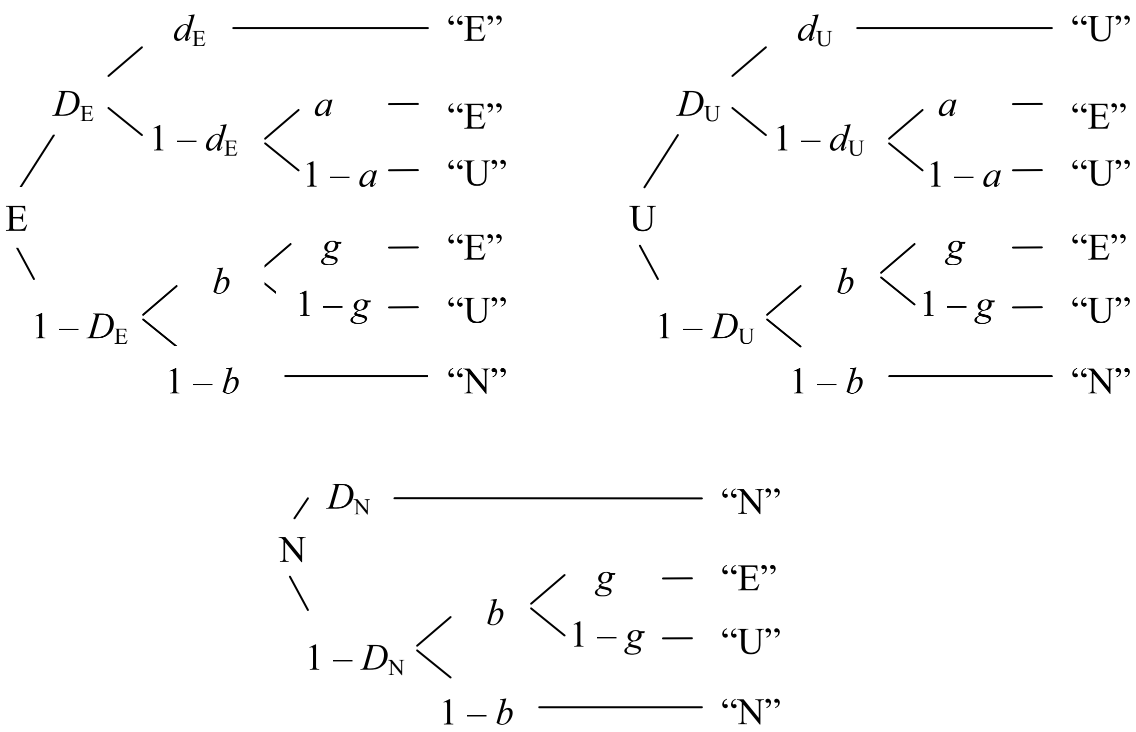

Figure A1. Two-high-threshold multinomial model of source monitoring (2HTSM, Bayen et al., 1996). E = item from the expected source, U = item from the unexpected source, N = new item. Participant responses are in quotation marks. D_E = probability of recognizing an item that had been presented by the expected source; D_U = probability of recognizing an item that had been presented by the unexpected source; D_N = probability of knowing that a new item is new; d_E = probability of remembering that an item had been presented by the expected source; d_U = probability of remembering that an item had been presented by the unexpected source; a = probability of guessing that a recognized item had been presented by the expected source; g = probability of guessing that an unrecognized item had been presented by the expected source; b = probability of guessing that an unrecognized item is old. Adapted from "Source discrimination, item detection, and multinomial models of source monitoring," by U. J. Bayen, K. Murnane, and E. Erdfelder, 1996, *Journal of Experimental Psychology: Learning, Memory,* *and Cognition, 22,* p. 202, Figure 3. Copyright 1996 by the American Psychological Association.

Appendix B: Response frequencies from Experiments 1 and 3

Table B1

Response frequencies for items from the schematically expected source, items from the schematically unexpected source, and new items in Experiment 1

Source	"Expected"	"Unexpected"	"New"
Expected	674	197	281
Unexpected	281	622	249
New	354	123	1827

Note. Expected = items from the expected source, Unexpected = items from the unexpected source, New = new items. Responses are in quotation marks.

Table B2

Response frequencies for child-expected and equally expected items in Experiment 3

	"House with children"	"House without children"	"New"
Source	Child-expected items		
House with children	314	117	145
House without children	144	318	114
New	156	83	913
Source	Equally expected items		
House with children	296	97	183
House without children	133	279	164
New	82	95	975

Note. House with children = items presented with the source house with children; House without children = items presented with the source house without children; New = new items. Responses are in quotation marks.

Appendix C: Multinomial-model parameter estimates for Experiments 1 and 3

Table C1

Parameter estimates, confidence intervals and G^2 *goodness-of-fit values of Submodel 5d and 5a (Experiment 1) and for child-expected and equally expected items (Experiment 3) of the two-high-threshold model of source monitoring*

Experiment 1							
	D	b	d_E	d_U	a	g	$G^2(1)$
Submodel 5d	.56 [.54, .59]	.47 [.45, .50]	.17 [-.07, .40]	.79 [.73, .86]	.74 [.70, .78]	.74 [.70, .78]	2.51
Submodel 5a	.56 [.54, .59]	.47 [.45, .50]	.63 [.57, .69]	.63 [.57, .69]	.42 [.32, .51]	.74 [.70, .78]	2.51
Experiment 3							
	D	b	d_E	d_U	a	g	G^2
Child-expected	.57 [.53, .60]	.48 [.44, .52]	.30 [.05, .55]	.71 [.60, .82]	.65 [.59, .71]	.65 [.59, .71]	4.80 (df = 1)
Equally expected	.55 [.51, .58]	.34 [.30, .37]	.55 [.47, .63]	.55 [.47, .63]	.53 [.49, .57]	.53 [.49, .57]	6.38 (df = 2)

Note. D = item recognition; d_E = probability of remembering that an item had been presented by the expected source; d_U = probability of remembering that an item had been presented by the unexpected source; a = probability of guessing that a recognized item had been presented by the expected source (Experiment 1) or probability of guessing "house with children" for a recognized item (Experiment 3); g = probability of guessing that an unrecognized item had been presented by the expected source (Experiment 1) or probability of guessing "house with children" for an unrecognized item (Experiment 3); b = probability of guessing that an unrecognized item is old. Submodel 5d assumes a = g = probability of schema-consistent guessing; Submodel 5a assumes $d_E = d_U$, i.e., equal source memory for both sources. 95% confidence intervals are in brackets. Critical values are $G^2(1) = 6.63$ for the 5-parameter model and $G^2(2) = 9.21$ for the 4-parameter model.

Article B:

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Attention and Source Memory

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Abstract

In two source-monitoring experiments, we tested predictions derived from the attention-elaboration hypothesis (AEH) and the theory of visual attention (TVA). The AEH predicts better source memory for unexpected sources (inconsistency effect) due to attention drawn to the unexpected sources. The TVA predicts better source memory for the source with a special feature due to attention drawn to this source. In Experiment 1, we used one expected and two unexpected sources expecting no difference in source memory, because both source types should receive additional attention (the expected source due to TVA; the unexpected sources due to AEH). Results showed equal source memory for expected and unexpected sources, supporting both theories. In Experiment 2, we used one unexpected and two expected sources and found better source memory for the unexpected source as predicted by both AEH and TVA. The ratio of expected and unexpected sources is, thus, a decisive factor determining the occurrence of inconsistency effects in source memory. The more attention is drawn towards a source, the better memory is for this source.

Keywords: schemas, source monitoring, inconsistency effect, attention-elaboration hypothesis, theory of visual attention

Attention and Source Memory

Every day, we meet new people, hear new information, and learn new things. In order to not be overwhelmed with the amount of new information, we use stereotypes, schemas, and general knowledge to organize, judge, and use new information (Alba & Hasher, 1983). Perhaps new information fitting in an existing schema like “Drinking a lot of alcohol every day is harmful to your health” does not extend your knowledge that much, whereas new information not fitting in a schema like “Working out every day is harmful to your health” does extend your existing knowledge and, therefore, should be memorized.

Better memory for information not fitting in existing schemas is proposed by the *attention-elaboration hypothesis* (AEH; Brewer & Treyens, 1981; Friedman, 1979; Loftus & Mackworth, 1978). The AEH states that schema-inconsistent information attracts more attention and is processed more deeply and elaborately than schema-consistent information. Therefore, it should be easier to remember schema-inconsistent information. Many studies support this prediction of the AEH revealing an *inconsistency effect* with better memory for schema-inconsistent than schema-consistent information (e.g., Erdfelder & Bredenkamp, 1998; Mäntylä & Bäckman, 1992; Vakil, Sharot, Markowitz, Aberbuch, & Groswasser, 2003).

To define whether information is schema consistent or schema inconsistent, the source of information is decisive. For example, the statement “I love you” is schema-consistent if your mother or partner says it, but schema-inconsistent if your boss says it. Thus, the connection between information itself and the source presenting it defines whether it is schema consistent or schema inconsistent. Therefore, Bayen, Nakamura, Dupuis, and Yang (2000) as well as Ehrenberg and Klauer (2005) extended the AEH, which had first been formulated for item-memory tasks, to source-monitoring tasks.

In typical source-monitoring tasks, participants are presented with items from two or more sources. At test, they indicate if any given test item is old or new, and if it is old which source presented it (Johnson, Hashtroudi, & Lindsay, 1993). Extending the AEH to source-monitoring tasks, Bayen et al. (2000) and Ehrenberg and Klauer (2005) proposed better source memory for unexpected sources. In line, Ehrenberg and Klauer, Gawronski, Ehrenberg, Banse, Zukova, and Klauer (2003) as well as Küppers and Bayen (2012b) found inconsistency effects in source memory with better memory for the unexpected sources. All of these studies used source-monitoring paradigms with two sources (e.g., skinhead and social worker, kitchen and bathroom) or two categories (e.g., female and male) as expected and unexpected sources.

Using more than two sources (e.g., three sources) could influence the occurrence of inconsistency effects as predicted by the *theory of visual attention* (TVA; Bundesen, 1990). The TVA states that if an object has a special feature (e.g., red color) in contrast to other objects (e.g., blue color), the object with the special feature attracts more attention. This phenomenon is known as the “pop-out” effect for the object with a special feature (e.g., Geyer, Zehetleitner, & Müller, 2010; West, Pun, Pratt, & Ferber, 2010). There is a connection between such “pop-out” of an object and performance in memory tasks with better memory for objects that have special features because of additional attention drawn to such objects at encoding (Fine & Minnery, 2009). In social psychology, the TVA is embedded in the account of comparative distinctiveness (Klauer, Wegener, & Ehrenberg, 2002) stating that relative group size influences memory performance. Klauer et al. (2002) found an increase in source memory for a person stereotype as relative group size of this stereotype decreased. Using one woman and seven men as sources and neutral statements as items, source memory for the woman was better than for the men (and vice versa using one man and seven women). The woman (or man) “pops out” in contrast to the men (or women). As Klauer et al. used neutral statements, they did not investigate source memory for expected or unexpected sources but effects of relative group size on source memory in general. Küppers and Bayen (2012a) investigated influences of the ratio of expected to unexpected sources on source memory for the first time. They successfully increased source memory for the expected source using one expected and two unexpected sources as well as more items presented with the expected than each of the unexpected sources. In conclusion, the ratio of expected and unexpected sources seems to influence attention drawn to the sources.

Summarizing, the AEH proposes better memory for unexpected sources because of attention drawn to unexpected information. Additionally, the TVA predicts an influence of the ratio of expected and unexpected sources. Using a single source of one type in contrast to more sources of another type should increase attention for the single source and as a consequence increase elaboration and memory for this source.

We conducted two experiments to test the influence of both hypotheses (AEH and TVA) on source memory systematically. To be able to test our hypotheses regarding source memory it is important to separate source memory from item memory and guessing. Batchelder and Riefer (1990) proposed multinomial models for source-monitoring tasks to yield independent measures of memory and guessing. Bayen, Murnane, and Erdfelder (1996) presented and validated the two-high-threshold multinomial model of source monitoring (2HTSM) for two sources, and many studies have used this model since (e.g., Bayen & Kuhlmann, 2011; Bayen & Murnane, 1996; Bayen et al., 2000; Bell, Buchner, Kroneisen, Giang, in press; Dodson, Darragh, & Williams, 2008; Ehrenberg & Klauer, 2005; Erdfelder & Bredenkamp, 1998; Klauer & Meiser, 2000; Kuhlmann, Vaterrodt, & Bayen, 2012; Meiser, Sattler, & von Hecker, 2007; Spaniol & Bayen, 2002; Yu & Bellezza, 2000). Riefer, Hu, and Batchelder (1994) extended Batchelder and Riefer's (1990) multinomial model for two sources to a model for three sources. The 2HTSM for three sources has been used to analyze data from a three-source paradigm regularly and successfully (Bell & Buchner, 2010a; Bell & Buchner, 2010b; Bell, Buchner, Erdfelder, Giang, Schain, & Riether, 2012; Bell, Buchner, & Musch, 2010; Buchner, Bell, Mehl, & Musch, 2009; Keefe, Arnold, Bayen, McEvoy, & Wilson, 2002). Therefore, we used the 2HTSM for three sources to separate item memory, source memory, and guessing in order to independently measure source memory and thereby the occurrence of inconsistency effects.

In Experiment 1, we used one expected and two unexpected sources. According to the AEH, there should be better memory for the unexpected sources because of additional attention drawn to unexpected information. In contrast, according to the TVA, there should be better memory for the single expected source because of additional attention drawn to the source with the special feature. Our predictions for the experiment were as follows. First of all, we expected no memory difference between both unexpected sources, because additional attention assumed by the AEH should be equal for both unexpected sources. Additionally, we expected no memory difference between expected and unexpected sources and, thus, no inconsistency effect, because both source types received additional attention (one because of unexpectedness, the other because of a special feature). That is, due to the effects postulated by AEH and TVA, both types of sources should be memorized quite well, and the two types of memory advantage may trade off to yield equal memory for expected and unexpected sources.

In Experiment 2, by contrast, we used two expected and one unexpected source. In this case, both AEH and TVA state better memory for the unexpected source. The AEH again postulates better memory for unexpected information; the TVA also postulates better memory for the unexpected source, because in this experiment, the unexpected source is the one with a special feature. We expected no memory difference between both expected sources, because none of them receives additional attention. Additionally, we expected better memory for the unexpected source than for the expected sources, that is, an inconsistency effect in source memory because both, AEH and TVA, postulated better memory for the unexpected source. The results of both experiments can, thus, reveal how differences in attention drawn to different sources influence source memory, as predicted by AEH and TVA.

Experiment 1

In Experiment 1, we used items that were very expected for one source and very unexpected for two other sources. We used the 2HTSM for three sources (Keefe et al., 2002) to yield a pure measure of source memory. We expected no differences in source memory and, thus, no inconsistency effect, because attention should be drawn to unexpected information (AEH) and to expected information (TVA) resulting in no memory differences in source memory, if these two effects trade off.

Method

Participants. Forty-eight (36 female) native speakers of German participated. Age ranged between 19 and 28 years ($M = 21.85$). For their participation, they received money or course credit.

Design. We used a 3 x 3 factorial design with the independent within-subject variables object expectancy (expected-kitchen vs. expected-bathroom vs. expected-nursery) and source (kitchen vs. bathroom vs. nursery). We used the memory parameters of the 2HTSM for three sources (Keefe et al., 2002) as dependent measures.

Materials. We used 108 object labels as items. One third of the objects was very expected for a kitchen and very unexpected for a bathroom and a nursery; one third was very expected for a bathroom and very unexpected for a kitchen and a nursery, and one third was very expected for a nursery and very unexpected for a bathroom and a kitchen. We chose 108 of the 144 items used by Küppers and Bayen (2012a) with mean expectancy ratings for the expected room of 4.34 and mean expectancy ratings for the unexpected rooms of 1.19 or 1.20. We divided each item pool of one type (e.g., expected-bathroom items) into three lists (A, B, and C) with 12 items each, to match study and test lists on expectancy. The three lists did not differ in mean expectancy ratings. For each participant, two lists of each item type were shown at study and the third list additionally as distractor items at test. Which lists appeared at study (A & B, A & C, or B & C) was counterbalanced.

Procedure. Each experimental session included between one and five participants. They signed a consent form and then read instructions for the study phase on the computer screen, including the information that item memory would be tested. Participants were not informed that source memory would be tested as well.

In the study list, each object label appeared above a source label for 4s. Object label and source were written in white capital letters on black background. Three item-source pairings served as primacy buffer, one with the kitchen source, one with the nursery source, and one with the bathroom source. After the primacy buffer, 72 item-source pairings (24 expected-kitchen items, 24 expected-nursery items, 24 expected-bathroom items) followed in an order that was randomized by participant. One third of the items appeared with their expected source, one third appeared with the first unexpected source, and one third appeared with the second unexpected source.

Instructions for the source-monitoring test followed after study. Six practice items preceded the test items. Three of them had appeared as primacy buffer in the study list, and three were new items. Test items included the 72 items shown in the study list and 36 new items (the bathroom, kitchen, and nursery lists that had not been shown at study), also presented in white capital letters on black background. Presentation order was again randomized by participant.

For each item the question “Which room was this object presented with?” was asked. There were four response options: “bathroom,” “kitchen,” “nursery,” and “neither,” written in colored capital letters. Participants gave their responses by pressing corresponding color-coded keys on the computer keyboard. We marked “D” with a blue sticker, “H” with a yellow sticker, and “L” with a green sticker for the three sources. Color assignment to the sources was counterbalanced across participants. The space bar was marked with a red sticker and always indicated the “neither” response.

After completing the memory test, participants made three frequency judgments. Participants were asked how many of the 24 expected-kitchen items were presented with kitchen at study, how many of the 24 expected-nursery items were presented with nursery, and how many of the 24 expected-bathroom items were presented with bathroom at study. The order of these three questions was counterbalanced. A demographic questionnaire and debriefing followed.

Results and Discussion

We used an alpha level of .05 for all statistical tests. To separate item memory, source memory, and guessing biases we used the 2HTSM for three sources (Keefe et al., 2002; see Appendix A for a figure and description). In line with Küppers and Bayen (2012a), we combined the data to expected and unexpected item-source pairings to clearly present the results. Response frequencies for Experiment 1 are shown in Table B1. We used multiTree (Moshagen, 2010) for the multinomial model-based analyses. We evaluated model fit using the goodness-of-fit statistic G^2 which is asymptotically chi-square distributed (Hu & Batchelder, 1994). G^2 values lower than the critical G^2 indicate good model fit.

Because no differences in item memory were expected, item memory for items from the expected source, items from both unexpected sources, and new items should be equal ($D_E = D_{U1} = D_{U2} = D_N = D$). In fact, a model that included these equality restrictions across item-memory parameters showed good fit to the data with $G^2(19) = 9.02$ (critical $G^2(19) = 30.14$).

Next, we tested whether there were differences in source memory between items from both unexpected sources. We expected no difference, because both unexpected sources should receive additional attention as predicted by the AEH. The model that included the equality restriction of source-memory parameters for the unexpected sources ($d_{U1} = d_{U2}$) showed no significant decrease in model fit with $\Delta G^2(1) = 3.80$ (critical $G^2(1) = 3.84$). Thus, there was no memory difference between both unexpected sources, as predicted.

The overall fit of this model was good with $G^2(20) = 12.81$ (critical value 31.41). We used this model as the base model against which we tested hypotheses regarding differences in source memory parameters between the expected source and the unexpected sources. Figure 1 shows the source-memory parameters for the items from the expected and unexpected sources. We found no differences in source memory between the expected source and the unexpected sources as there was no significant decrease in model fit setting $d_E = d_U$ ($\Delta G^2(1) = 0.03$, critical $G^2(1) = 3.84$). In conclusion, there was no memory difference between expected and unexpected sources when we used one expected and two unexpected sources, as predicted. Attention was drawn to the unexpected sources as postulated by the AEH as well as to the expected source as postulated by the TVA trading off to no memory differences and, thus, no inconsistency effect in source memory.

Experiment 2

In Experiment 2, we used items that were very expected for two sources and very unexpected for the other source. Again, we used the 2HTSM to yield pure measures of source memory. We expected better memory for the unexpected source than the expected sources revealing an inconsistency effect in source memory because both AEH and TVA predict better memory for the unexpected source.

Method

Participants. Forty-eight native speakers of German (36 female) participated. Age ranged between 18 and 35 years ($M = 23.00$). Two participants were excluded because they did not use all of the response options and we, thus, presumed they did not follow instructions. As compensation for their participation, they received money or course credit. None of them had participated in the previous experiment.

Design. All objects were expected for both balcony and garden. Source was manipulated as an independent variable with three levels (balcony vs. garden vs. bathroom). As in Experiment 1, we used the memory parameters of the 2HTSM for three sources (Keefe et al., 2002) as dependent measures.

Materials. To find out whether an item was very expected for a balcony and a garden, and very unexpected for a bathroom, we conducted a norming study following the procedures of the norming studies performed by Bayen et al. (2000), Kuhlmann et al. (2012), and Küppers and Bayen (2012a, 2012b). We generated 311 labels of objects that can be found on a balcony, in a garden, or in a bathroom. One-hundred and five participants (21 male) rated these object labels regarding their expectancy for either a balcony, a garden, or a bathroom (with about equal numbers of participants in each scene condition) on a 5-point Likert scale (1 = *very unexpected*, 2 = *somewhat unexpected*, 3 = *neither unexpected nor expected*, 4 = *somewhat expected*, 5 = *very expected*). We excluded two participants, because they converted the scale towards 1 (*very expected*) and 5 (*very unexpected*). To select objects that are very expected for a balcony and a garden, and very unexpected for a bathroom, we chose items with a mean expectancy rating of 3.50 or greater for the expected sources (balcony and garden) and 1.80 or less for the unexpected source (bathroom). Items had a mean expectancy rating for garden of 4.22, for balcony of 4.07 and for bathroom of 1.19. To match study and test lists on expectancy, we divided the items into three lists (A, B, and C) with 12 items each. The three lists did not differ in mean expectancy ratings.

Procedure. The procedure differed from Experiment 1 in some points. Firstly, only 24 item-source pairings appeared in the study list, for 2.5 s each. One third of the items appeared with balcony, one third with garden, and one third with bathroom as source. Secondly, test items were the 24 items that had appeared in the study list and 12 new items. Thirdly, response options at test were “balcony,” “garden,” “bathroom,” and “neither.”

Results and Discussion

As in Experiment 1, we combined data to expected and unexpected item-source pairings and used the 2HTSM for three sources to analyze the data. Response frequencies for Experiment 2 are shown in Table B1.

As in Experiment 1, we expected no differences in item memory for items from both expected sources, items from the unexpected source, and new items ($D_{E1} = D_{E2} = D_U = D_N = D$). In fact, the model that included these equality restrictions across item-memory parameters showed good fit to the data with $G^2(19) = 25.39$ (critical value 30.14).

In a next step, we tested whether there were differences in source memory between items from both expected sources. We expected no such differences, because both expected sources should not receive additional attention according to the AEH and TVA. The model including the equality restriction across both expected sources of source memory parameters ($d_{E1} = d_{E2}$) showed no significant decrease in model fit with $\Delta G^2(1) = 0.81$ (critical value 3.84). Thus, there was no difference in source memory between the two expected sources, as predicted.

We used this model with the equality restriction $d_{E1} = d_{E2}$ as the base model against which we tested the hypothesis regarding differences in source-memory parameters between the expected source and the unexpected sources (model fit: $G^2(20) = 26.20$; critical $G^2(20) = 31.41$). Figure 1 shows source-memory parameters for items from the unexpected and expected sources. Setting $d_E = d_U$, we found a significant decrease in model fit ($\Delta G^2(1) = 7.57$, critical value 3.84) indicating higher source memory for the unexpected source than the expected sources. In conclusion, we found an inconsistency effect in source memory revealing better memory for the unexpected source as predicted by the AEH and TVA.

General discussion

In two source-monitoring experiments, we tested predictions of the attention-elaboration hypothesis and the theory of visual attention. The AEH proposes better source memory for unexpected sources (inconsistency effect) due to attention drawn to unexpected information. The TVA proposes better source memory for the source with a special feature in contrast to other sources presented at study due to attention drawn to the source with a special feature.

In Experiment 1, we used one expected and two unexpected sources to test predictions of both theories. In this case, the AEH proposes better source memory for both unexpected sources, whereas the TVA proposes better source memory for the expected source. Both memory boosts should occur due to attention drawn to the respective source type. We found no memory differences in source memory suggesting that both AEH and TVA are valid and that the effects they predict traded off.

In Experiment 2, we used one unexpected and two expected sources. In this case, both the AEH and TVA propose better source memory for the unexpected source due to attention drawn to the unexpected source because of both unexpectedness and special feature. We did indeed find better source memory for the unexpected source than the expected sources via multinomial modeling.

In conclusion, our results support the AEH and the TVA. Source memory seems to be influenced by attention drawn to the different kinds of sources. While unexpected sources attract attention due to their unexpectedness as proposed by the AEH, expected and unexpected sources can attract attention due to a special feature depending on the ratio of expected and unexpected sources. As a consequence, the occurrence of inconsistency effects in source-monitoring tasks depends on the ratio of expected and unexpected sources. Using more unexpected than expected sources (as in Experiment 1), can prevent the occurrence of inconsistency effects.

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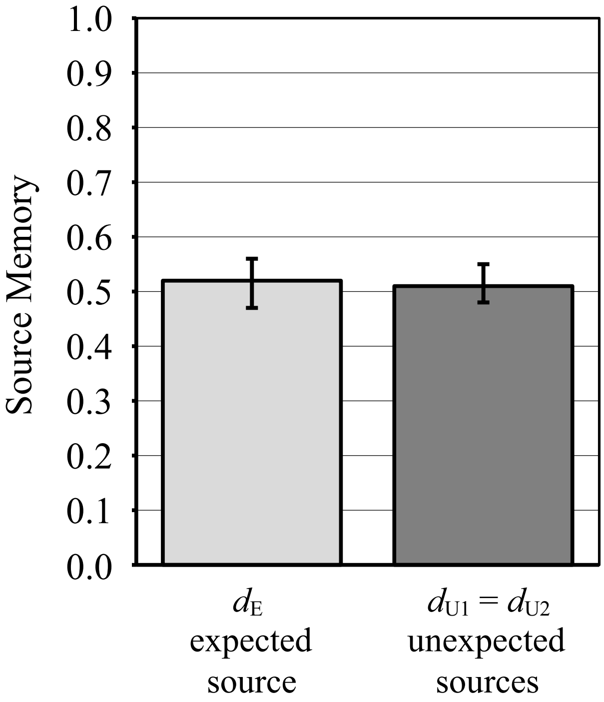

Figure 1. Source memory as a function of expectancy in Experiment 1. d_E = probability of remembering the source of an item that had been presented by the expected source; d_{U1} = probability of remembering the source of an item that had been presented by the first unexpected source; d_{U2} = probability of remembering the source of an item that had been presented by the second unexpected source. Error bars indicate 95% confidence intervals.

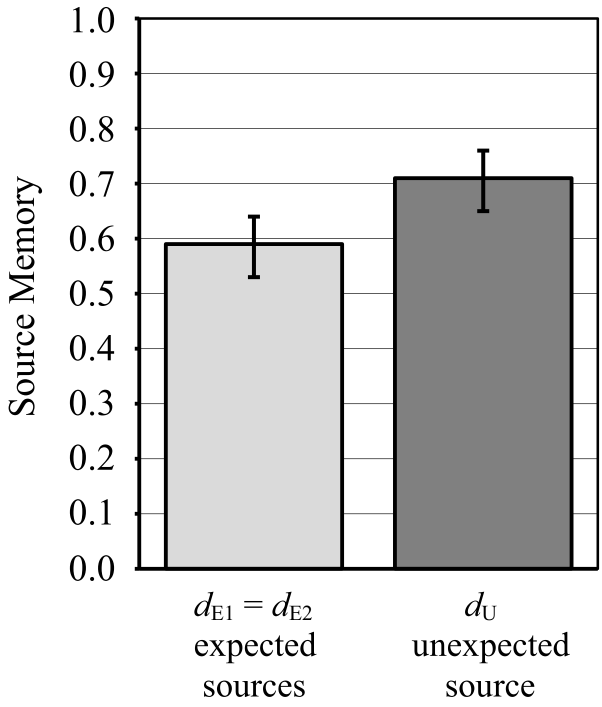

Figure 2. Source memory as a function of expectancy in Experiment 2. d_{E1} = probability of remembering the source of an item that had been presented by the first expected source; d_{E2} = probability of remembering the source of an item that had been presented by the second expected source; d_U = probability of remembering the source of an item that had been presented by the unexpected source. Error bars indicate 95% confidence intervals.

Appendix A: Two-high-threshold multinomial model of source monitoring for three sources

Figure A1 illustrates the 2 HTSM for three sources (Keefe et al., 2002). In a source-monitoring task with three sources, an item can be presented with Source A, Source B, Source C, or it is new. For each item, there are the four response options: “Source A,” “Source B,” “Source C,” and “new.”

The first tree in Figure A1 represents items that had been presented with Source A at study. With probability D_A, participants recognize that these items as old items. With probability d_A, they can also remember the source (Source A) these items had been presented with. With probability $1 - d_A$, they cannot remember the source. In this case, they have to guess an answer. With probability a_A, they guess “Source A”; with probability a_B, they guess “Source B”; with probability a_C, they guess “Source C.” With probability $1 - D_A$, participants cannot correctly recognize the items and must guess. With probability b, they guess that items are old; with probability $1 - b$, they guess that items are new. If participants guess that items are old (b), they guess with probability g_A, “Source A”; with probability g_B, “Source B”; and with probability g_C, “Source C.”

The second tree represents items that had been presented with Source B, the third tree items that had been presented with Source C, and the fourth tree items that had not been presented in the study list and are, thus, new. With probability D_N, participants know that items are new; with probability $1 - D_N$, they do not know that items are new. In this case, they guess with probability b that items are old and with probability $1 - b$ that they are new.

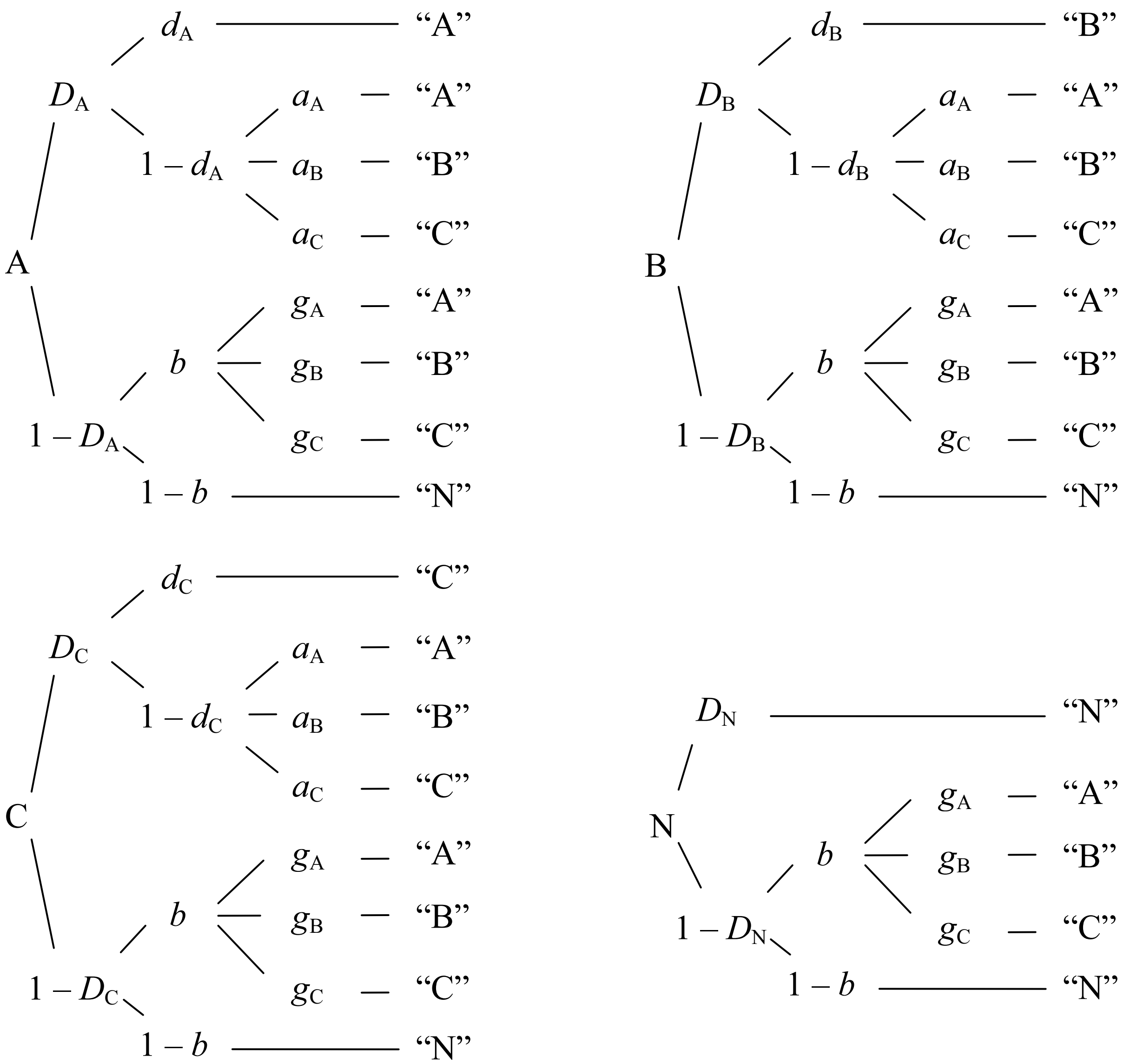

Figure A1. The 2HTSM for three sources (Keefe et al., 2002). A = item from Source A, B = item from Source B, C = item from Source C, N = new item. Participant responses are in quotation marks. D_A = probability of recognizing an item that had been presented by Source A; D_B = probability of recognizing an item that had been presented by Source B; D_C = probability of recognizing an item that had been presented by Source C; D_N = probability of knowing that a new item is new; d_A = probability of remembering that an item had been presented by Source A; d_B = probability of remembering that an item had been presented by Source B; d_C = probability of remembering that an item had been presented by Source C; a_A =

probability of guessing that a recognized item had been presented by Source A; a_B = probability of guessing that a recognized item had been presented by Source B; a_C = probability of guessing that a recognized item had been presented by Source C; b = probability of guessing that an unrecognized item is old; g_A = probability of guessing that an unrecognized item had been presented by Source A; g_B = probability of guessing that an unrecognized item had been presented by Source B; g_C = probability of guessing that an unrecognized item had been presented by Source C. Adapted from "Response strategies in source monitoring," by D. M. Riefer, X. Hu, and W.H. Batchelder, 1994, *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20,* p. 686. Copyright 1994 by the American Psychological Association.

Appendix B: Response frequencies from Experiments 1 and 2

Table B1

Response frequencies for the different types of items in Experiments 1 and 2.

Experiment 1				
Source	"Expected"	"Unexpected$_1$"	"Unexpected$_2$"	"New"
Expected	481	148	144	379
Unexpected$_1$	168	461	122	401
Unexpected$_2$	172	169	434	377
New	122	81	61	1464
Experiment 2				
Source	"Expected$_1$"	"Expected$_2$"	"Unexpected"	"New"
Expected$_1$	213	75	33	47
Expected$_2$	64	197	32	75
Unexpected	63	54	188	63
New	46	47	25	434

Note. Expected = item from an expected source, Unexpected = item from an unexpected source, New = new items. Responses are in quotation marks.

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Guessing Biases in Source Monitoring: Compensatory or Schema Based?

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Abstract

In source-monitoring experiments, compensatory guessing favoring a less remembered source, and schema-based source guessing may occur. The authors investigated which guessing bias prevails when both compete. In two source-monitoring experiments, for each item, one source was schematically expected, and one or two sources were schematically unexpected. Better source memory for the expected source was achieved via manipulations of presentation time (Experiment 1) and number of expected versus unexpected sources (Experiment 2). A compensatory-guessing hypothesis predicted a schema-inconsistent guessing bias, whereas a schema-based guessing hypothesis predicted a schema-consistent guessing bias. Results support the schema-based guessing hypothesis.

Keywords: schemas, source monitoring, response bias, multinomial modeling

Guessing biases in source monitoring: Compensatory or schema based?

In everyday life, we use stereotypes, schemas and general knowledge to organize, judge, and use new information (Alba & Hasher, 1983). How trustworthy or useful such new information seems, may depend on its source. While medical advice given by a doctor may be trustworthy and useful, the same advice given by a banker or a teacher may be less trustworthy and, therefore, less useful. Thus, the source of information is an important criterion for trustworthiness and usefulness of information.

Johnson, Hashtroudi, and Lindsay (1993) defined source monitoring as “the set of processes involved in making attributions about the origins of memories, knowledge, and beliefs” (p. 3). In the typical experimental paradigm, participants are exposed to information that originates from two or more different sources. In a later source-monitoring test, participants are presented with test items of which some appeared at study, and others did not. Participants are instructed to indicate if a test item is old or new, and if they think it is old, which source presented the item. Correct source identification in this paradigm may be based on source memory or on correct source guessing. To judge how trustworthy a source-monitoring answer is, for example, in the context of a court testimony, it is important to distinguish answers that are based on memory from answers that are based on mere guessing. Obviously, a memory-based answer is much more trustworthy than a guessing-based answer. Therefore, the investigation of conditions influencing guessing biases in source monitoring is very important.

A number of studies have investigated schema-based guessing bias when the sources activated schemas (e.g., Bayen, Nakamura, Dupuis, & Yang, 2000; Mather, Johnson, & De Leonardis, 1999; Sherman & Besenoff, 1999). In a typical source-monitoring experiment to investigate schema-based bias, the combination of a given information and the source it originates from may be expected (such as a physician talking about mathematical calculations), it may be unexpected (such as a physician talking about medicine), or it may be neutral (such as a physician talking about the weather or a vacation). If we cannot remember the true source of information, we may use our schematic knowledge to guess a source. This guessing may be schema-consistent (towards the expected source), it may be schema-inconsistent (towards the unexpected source), or it may be at chance.

Three different types of guessing bias have been proposed in the literature. These are 1. contingency-based guessing, 2. compensatory guessing, and 3. schema-based guessing. We will discuss these three types of guessing biases in source monitoring in turn.

Batchelder and Batchelder (2008), and Wegener (2000) proposed a *base-rate* oriented guessing bias. Batchelder and Batchelder named it *base rate* heuristic and Wegener named it *contingency-based* guessing. If participants recognize a contingency or base rate (e.g., the contingency of expected and unexpected item-source pairings), they will use this information as a heuristic to adjust their guessing bias accordingly. That is, participants adjust their source guessing to the perceived ratio of expected to unexpected item-source pairings. If participants perceive a schema-consistent contingency with more expected than unexpected item-source pairings, there will be a schema-consistent guessing bias towards the expected source. If participants perceive a schema-inconsistent contingency with more unexpected than expected item-source pairings, there will be a schema-inconsistent guessing bias towards the unexpected source. If participants perceive a schema-neutral contingency with the same number of expected and unexpected item-source pairings, there will be guessing at chance level. A large body of research supported the contingency-based guessing hypothesis (Bayen & Kuhlmann, 2011; Ehrenberg & Klauer, 2005; Hicks & Cockman, 2003; Klauer & Meiser, 2000; Klauer & Wegener, 1998; Kuhlmann, Vaterrodt, & Bayen, 2012; Mather et al., 1999; Spaniol & Bayen, 2002) showing guessing probabilities according to the (perceived) item-source contingency in the respective experiment.

Batchelder and Batchelder (2008) proposed a second heuristic named *cause* heuristic. The cause heuristic involves a guessing bias influenced by participants' impressions about their own memory. If participants remember an item category or a source category better than another category, guessing will occur towards the less remembered category. Ehrenberg and Klauer (2005) and Küppers and Bayen (2012) referred to this heuristic as *compensatory* guessing because it compensates for poor memory for a category. Riefer, Hu, and Batchelder (1994) found compensatory guessing in two source-monitoring experiments. They used the generation effect in one experiment and showed a guessing bias towards "the other person generated the item" rather than "I generated the item." The experiment using the picture superiority effect showed a guessing bias towards "word" rather than "picture." Meiser, Sattler, and von Hecker (2007) also reported compensatory guessing. They manipulated memory via presentation time and presentation frequency. Guessing bias occurred towards the less remembered categories "short presentation time" and "rarely shown."

Bayen et al. (2000), Klauer, Wegener, and Ehrenberg (2002), and Wegener (2000) proposed a third guessing bias, namely *schema-based* guessing. This type of bias occurs when a schema or stereotype is activated for a source (like a doctor), and participants guess towards the expected source resulting in a schema-consistent bias. Bayen et al. supported the schema-based guessing hypothesis using two scenes (bathroom and bedroom) and objects that were expected for one scene and somewhat unexpected for the other scene. When participants could not remember the source of an object, they guessed the expected scene resulting in a schema-consistent guessing bias. Klauer et al. found a schema-consistent guessing bias using men in their early twenties and men in their midforties as sources, and conservative and progressive statements of gender roles in society as items. When participants could not remember the source of a statement, they guessed the expected source (younger men for progressive statements, and older men for conservative statements).

Some studies investigating the influence of schemas and stereotypes on source memory found an inconsistency effect in source memory, that is, better source memory for unexpected than expected sources (Ehrenberg & Klauer, 2005; Gawronski, Ehrenberg, Banse, Zukova, & Klauer, 2003; Küppers & Bayen, 2012; Stangor & McMillan, 1992). In addition, these studies showed schema-consistent guessing bias. Although Ehrenberg and Klauer (2005), Gawronski et al. (2003), and Küppers and Bayen (2012) used the same number of expected and unexpected item-source pairings, a schema-consistent guessing bias occurred. With such a zero contingency, the contingency-based guessing hypothesis would predict guessing at chance level. Küppers and Bayen used frequency judgments to investigate participants' contingency perception. The results showed correct perception of the zero contingency. Thus, although participants recognized the zero contingency, they guessed in a schema-consistent direction and no contingency-based guessing occurred.

An explanation for the lack of contingency-based guessing might be the expectancy strength of the used materials. Gawronski et al. (2003), and Stangor and McMillan (1992) found a connection between expectancy strength and memory. That is, increasing expectancy strength increased memory for unexpected information (inconsistency effect). For example, Bayen et al. (2000) used items which were only somewhat unexpected for one of the sources (e.g., clothes for bathroom, or medicine for bedroom) and found no inconsistency effect. Küppers and Bayen (2012) increased expectancy strength by using items which were very expected for one source and very unexpected for the other source (e.g., toilet and oven for the sources bathroom and kitchen) and found an inconsistency effect in source memory. In studies finding contingency-based guessing (Bayen & Kuhlmann, 2011; Klauer & Meiser, 2000; Klauer & Wegener, 1998; Kuhlmann et al., 2012; Spaniol & Bayen, 2002), items for which one source was only somewhat unexpected were used. No source-memory differences occurred in these studies. Maybe expectancy strength influences both memory and guessing. If expectancy strength is low, there are no memory differences but contingency-based guessing. If expectancy strength is high, there is better memory for unexpected sources and no contingency-based guessing (Küppers & Bayen, 2012). The results of Ehrenberg and Klauer (2005), Gawronski et al. (2003), and Küppers and Bayen (2012) of better memory for unexpected sources and schema-consistent guessing biases do not support a contingency-based guessing hypothesis, but they are in line with both a compensatory-guessing hypothesis and a schema-based guessing hypothesis. The results are in line with compensatory guessing, because better source memory for unexpected sources and an opposite schema-consistent guessing bias occurred. Alternatively, the results can be explained with a schema-based guessing bias, because schema-consistent guessing occurred. Thus, both explanations (compensatory guessing and schema-based guessing) can explain the results of these studies.

We conducted two experiments to test which influence on guessing (compensatory-guessing or schema-based guessing) is stronger. It is important to investigate such guessing processes for a better understanding of human response strategies. If the influence of compensatory guessing is stronger than the influence of schema-based guessing, a compensatory guessing bias towards the unexpected source occurs. In this case, people might recognize their better memory for one response category and strategically guess the other response. If the influence of schema-based guessing is stronger than the influence of compensatory guessing, a schema-based guessing bias towards the expected source occurs. In this case, people follow schemas very strictly in their guessing behavior.

To test both hypotheses against each other, we designed two experiments in which we manipulated the memorability of sources such that there would be better source memory for the expected than the unexpected source. If the influence of compensatory guessing is stronger than the influence of schema-based guessing, better source memory for the expected source should lead to schema-inconsistent guessing bias towards the unexpected source. If, however, the influence of schema-based guessing is stronger than the influence of compensatory guessing, then we would expect schema-consistent guessing bias towards the expected source.

Experiment 1

In Experiment 1, we used two sources, and items that were very expected for one source and very unexpected for the other source. We increased source memory via longer presentation time for expected item-source pairings compared to unexpected ones. To investigate guessing biases, we used two different conditions. In one condition, we included an "I don't know" response option as done by Dodson (2007), Dodson, Darragh, and Williams (2008), Gallo and Roediger (2003), Lampinen, Neuschatz, and Payne (1999), and Payne, Elie, Blackwell, and Neuschatz (1996). If participants did not remember the correct source, they had the option to answer "I don't know" instead of guessing a source. The second condition was a standard source-monitoring condition, in which there was no such "I don't know" response option. In this condition, when participants did not remember the source, they had to guess a source. The comparison of both conditions showed whether "expected" responses, "unexpected" responses or both increased, when no "I don't know" response option existed.

A greater increase in the "expected" response option compared to the "unexpected" response option would show a schema-consistent guessing bias and, thus, support the schema-based guessing hypothesis. A greater increase in the "unexpected" response option compared to the "expected" response option would show a schema-inconsistent guessing bias and, thus, support the compensatory-guessing hypothesis. Equal increase in both response options would show guessing at chance level and, thus, support neither the compensatory- nor the schema-based guessing hypothesis or would show that influences of compensatory and schema-based guessing are equally large and trade off.

Method

Participants. Ninety-one native speakers of German (42 male) participated. Age ranged between 18 and 33 years ($M = 22.34$ years). They received course credit or money as compensation for their participation.

Design and Materials. We used a 2 x 2 x 2 mixed design with the independent within-subjects variables expectancy (expected-bathroom vs. expected-kitchen) and source (bathroom vs. kitchen) and the between-subjects variable response condition (condition with "I don't know" response option versus typical source-monitoring condition without "I don't know" response option). We used 96 object names as items. Half of the objects were, according to a norming study by Küppers and Bayen (2012), very expected for a kitchen and very unexpected for a bathroom (e.g., refrigerator); the other half was very expected for a bathroom and very unexpected for a kitchen (e.g., bathtub). We used the materials developed and used by Küppers and Bayen (2012). They divided the item pool of each item type into two item lists with 24 items each. At study, four item-list combinations (Bathroom Lists A and B crossed with Kitchen Lists A and B) were approximately counterbalanced across participants.

Procedure. Each experimental session included between one and five participants who were seated in individual computer booths. They signed a consent form and then read instructions for the study phase on the computer screen. They were informed that their item memory would be tested, but were not informed that their source memory would also be tested.

The study phase had two parts. In the first part, we presented items only, such that item memory would be high enough to reliably measure source memory. In the second part, we presented the same items with their sources. In the first part, 48 object labels (24 expected-bathroom items and 24 expected-kitchen items) appeared for 3s each on the computer screen in an order that was randomized by participant. In the second part, these same items appeared in a new randomized order for another period of time. Half of them appeared for another 1s, simultaneously with their unexpected source. The other half of the items appeared for another 3s, simultaneously with their expected source. Object label and source were written in white capital letters on black background. We used the same four object labels as primacy buffer in the first and second part of the study list. These four object labels were expected for both a kitchen and a bathroom (e.g., door or window). In the second part, two randomly chosen primacy items appeared with the source "bathroom" (one for 1s and one for 3s, assigned at random), and two with the source "kitchen" (again one for 1s and one for 3s).

After study, instructions for the source-monitoring test were given. Four practice items preceded the test items. Two of them were new, and two of them had appeared as part of the primacy buffer in the study list. The actual test items included the 48 object labels shown at study and 48 new object labels (the bathroom and kitchen lists not shown at study). Object labels were again shown in white capital letters on black background. Their order was again randomized by participant.

For each test item, first the question "Did you already see the object in the study list?" was asked. There were two response options, namely "yes" or "no." If participants answered with "yes," the question "Which room was this object presented with?" was asked. In the condition with the "I don't know" response option, three responses were possible: "bathroom," "kitchen," or "I don't know." In the standard condition without the "I don't know" response option, two responses were possible, namely "kitchen" or "bathroom." Response options were written in color-coded capital letters. Participants gave responses by pressing corresponding color-coded keys on the computer keyboard. "D" was marked with a green sticker and "K" with a yellow sticker and indicated the answers "yes" and "no," as well as "bathroom" and "kitchen." Which color indicated "yes" or "no," and "bathroom" or "kitchen" was counterbalanced across participants. In the condition with the "I don't know" option, the space bar was marked with a red sticker and indicated the answer "I don't know." In the standard condition, no red key existed.

After completing the memory test, participants made two frequency judgments. They were asked how many of the 24 expected-bathroom items were presented with bathroom in the study list, and how many of the expected-kitchen items were presented with kitchen. The order of these two questions was counterbalanced. A demographic questionnaire and the debriefing followed.

Results

We combined the data for expected item-source pairings (expected kitchen and expected bathroom) and unexpected item-source pairings (unexpected kitchen and unexpected bathroom), as done by Kuhlmann et al. (2012), Küppers and Bayen (2012), and Spaniol and Bayen (2002). Absolute response frequencies from Experiment 1 are shown in Table A1. To investigate source memory and guessing bias, we used a relative frequency, namely the frequency of responses of one type relative to the frequency of "old" responses to items of one type:

$$f_i = \frac{Y_{ij}}{Y_{iold}} \qquad \text{(Equation 1)}$$

where Y_{ij} indicates the frequency of responses of type j to items of type i and Y_{iold} indicates all "old" responses to items of type i. In the condition with the "I don't know" response option, "old" responses included "expected," "unexpected," and "I don't know" responses; in the condition without the "I don't know" response option, "old" responses included "expected" and "unexpected" responses. Figure 1 shows f_i of "expected" and "unexpected" responses for items that had been presented with the expected source and items that had been presented with the unexpected source for both conditions.

We used the condition with the “I don’t know” response option to investigate source memory for expected and unexpected item-source pairings, because source-identification performance in this condition was presumably less influenced by guessing. As a measure of source identification, we used a special case of f_i, namely the Conditional Source Identification Measure (CSIM, Murnane & Bayen, 1996), which is the frequency of correct source identifications relative to the correct “old” responses to items of one type.

For the expected for source:

$$\text{CSIM}_{\text{E}} = \frac{Y_{\text{EE}}}{Y_{\text{EE}} + Y_{\text{EU}} + Y_{\text{E I don't know}}} \qquad \text{(Equation 2);}$$

for the unexpected source:

$$\text{CSIM}_{\text{U}} = \frac{Y_{\text{UU}}}{Y_{\text{UE}} + Y_{\text{UU}} + Y_{\text{U I don't know}}} \qquad \text{(Equation 3).}$$

We found significantly higher CSIM values for the expected source (CSIM_{E} = .57, *SD* = .22) than for the unexpected source (CSIM_{U} = .43, *SD* = .16), $t(45) = 3.64$, p =. 001, $d = 0.61$, suggesting better source memory for the expected source.

In a next step, we investigated source guessing biases. In the condition with the “I don’t know” response option, source guessing should be rare, because participants could choose the “I don’t know” response option when they did not remember the source. By contrast, in the condition without the “I don’t know” response option, participants had to guess a source when they did not remember it. The comparison of both conditions could show whether “expected” responses, “unexpected” responses, or both increased, when no “I don’t know” response option existed.

We performed a repeated-measures ANOVA with the relative frequency f_i (see Equation 1) as the dependent variable. Independent variables were the within-subject variables expectancy (items from the expected source vs. items from the unexpected source) and response ("expected source" vs. "unexpected source"), and the between-subjects variable response condition (condition with the "I don't know" response option vs. condition without the "I don't know" response option). There was no main effect of expectancy, $F(1,89) = 0.10$, $p = .75$, $\eta_p^2 = .001$, no interaction of expectancy and response condition, $F(1,89) = 0.15$, $p = .70$, $\eta_p^2 = .002$, a significant main effect of response, $F(1,89) = 54.37$, $p < .001$, $\eta_p^2 = .38$, and most importantly a significant interaction of response and response condition, $F(1,89) = 4.90$, $p = .03$, $\eta_p^2 = .05$. Additionally, we found a significant interaction of expectancy and response, $F(1,89) = 190.29$, $p < .001$, $\eta_p^2 = .68$, and no interaction between expectancy, response, and response condition, $F(1,89) = 0.01$, $p = .93$, $\eta_p^2 < .001$.

To investigate the interaction of response and response condition more closely, we performed *t* tests. We used the Bonferroni correction to set $\alpha = .05/4 = .0125$. We found a significantly higher ratio of "expected" responses in the condition without the "I don't know" response option than in the condition with the "I don't know" response option for items that had been presented with the expected source, $t(82.24) = 4.90$, $p < .001$, $d = 1.04$, and for items that had been presented with the unexpected source, $t(89) = 4.92$, $p < .001$, $d = 1.06$. By contrast, we found no significant difference in the ratio of "unexpected" responses between the condition without the "I don't know" response option and the condition with the "I don't know" response option for items that had been presented with the expected source, $t(89) = 2.07$, $p = .04$, $d = 0.45$, and for items that had been presented with the unexpected source, $t(89) = 1.84$, $p = .07$, $d = 0.35$.

Frequency judgments in the condition with the "I don't know" response option were significantly higher than the correct value of 12, with a mean of 14.78 ($SD = 3.66$) for expected-bathroom items, $t(45) = 5.15$, $p < .001$, $d = 0.76$, and a mean of 14.76 ($SD = 4.05$) for expected-kitchen items, $t(45) = 4.63$, $p < .001$, $d = 0.68$. Frequency judgments in the condition without the "I don't know" response option were also higher than the correct value of 12, with a mean of 14.53 (SD = 4.48) for expected-bathroom items, $t(44) = 3.80$, $p < .001$, $d = 0.56$, and a mean of 13.96 (SD = 4.10) for expected-kitchen items, $t(44) = 3.20$, p .003, $d = 0.48$.

Discussion

Concerning source memory, we found significantly higher CSIM for the expected than the unexpected source in the condition with the "I don't know" response option. Thus, assuming that CSIM mostly measures source memory (and not guessing) in this condition, the manipulation to strengthen source memory for the expected source via longer presentation times was successful. Since our manipulation yielded better source memory for the expected source, we were able to investigate if a compensatory guessing bias (in this case schema-inconsistent guessing) or a schema-based consistent guessing bias occurred. The comparison of the response conditions revealed a significantly higher ratio of "expected" responses when the "I don't know" response option was not available. By contrast, we found no significant difference in the ratio of "unexpected" responses between conditions. When participants had to guess because no "I don't know" response option existed, they predominantly chose the expected source instead of the unexpected source. In conclusion, a schema-consistent guessing bias instead of a compensatory schema-inconsistent guessing bias occurred. Therefore, the schema-based guessing hypothesis was supported, whereas the compensatory-guessing hypothesis was not.

Frequency judgments showed a bias towards more perceived expected item-source pairings. Thus, participants did not correctly recognize the zero contingency but perceived more expected than unexpected item-source pairings with a mean percentage of 60% expected and 40% unexpected item-source pairings.

Experiment 2

With the *I don't know* procedure, it is still possible that participants guess responses instead of answering "I don't know," and it can, therefore, not be assumed to provide pure measures of source memory and guessing. Therefore, in Experiment 2, we used a multinomial model of source monitoring (Bayen, Murnane, & Erdfelder, 1996) which provides pure measures of source memory and guessing in the source-monitoring paradigm. The multinomial model for two sources (as presented by Bayen et al., 1996) is unable to show whether a difference in source memory for expected and unexpected sources exists. This is because Submodel 5d which assumes a source-memory difference is equivalent to Submodel 5a which assumes a difference in guessing biases. That is, these alternative submodels always have the same model fit (for details, see Batchelder & Riefer, 1990; Bayen et al., 1996; Riefer et al., 1994). Therefore, we used three sources. The multinomial model for three sources allows us to investigate item memory, source memory, and two different source-guessing biases simultaneously (Riefer et al., 1994).

In Experiment 2, we used a single expected source and two unexpected sources to increase source memory for the expected source, as Klauer et al. (2002) found an increase in source memory for a person stereotype as relative group size of this stereotype decreased. When they used one single woman and seven men as sources, source memory for the single woman was better than for the men. Therefore, we used a single expected source and two unexpected sources. Additionally, we used a zero contingency to increase comparability with Experiment 1 and other experiments using two instead of three sources. That is, we presented half of the items with the expected source and half of the items with the unexpected sources (one quarter with each of the unexpected sources). With better source memory for the expected source, we intended to investigate whether there would be schema-consistent guessing bias towards the expected source or compensatory guessing biases towards one or both unexpected sources.

Method

Participants. Forty-eight students (36 female) participated, all of them native speakers of German. Age ranged between 19 and 30 years (*M* = 23.54 years). For their participation, they received money or course credit. None of them had participated in the first experiment.

Design. We used a 3 x 3 factorial design with the independent within-subject variables object expectancy (expected-kitchen vs. expected-bathroom vs. expected-nursery) and source (kitchen vs. bathroom vs. nursery). We used the memory and guessing parameters of the two-high-threshold multinomial model of source monitoring for three sources (Keefe, Arnold, Bayen, McEvoy, & Wilson, 2002) as dependent measures.

Materials. We used 144 object labels as items. One third of the objects were very expected for a kitchen and very unexpected for a bathroom and a nursery; one third were very expected for a bathroom and very unexpected for a kitchen and a nursery, and one third were very expected for a nursery and very unexpected for a bathroom and a kitchen.

To find out whether an item is very expected for one room and very unexpected for the two other rooms, we conducted a norming study. We followed the procedures of the norming studies performed by Bayen et al. (2000), and Küppers and Bayen (2012). We generated 894 German labels of objects that can be found in either a kitchen, a bathroom, a nursery, or an office. A total of 181 participants (122 female) rated these object labels regarding their expectancy for either a kitchen, a bathroom, a nursery, or an office (with about equal numbers of randomly assigned participants in each scene condition) on a 5-point Likert scale (1 = *very unexpected*, 2 = *somewhat unexpected*, 3 = *neither unexpected nor expected*, 4 = *somewhat expected*, 5 = *very expected*). We excluded five participants because they converted the scale to 1 (*very expected*) and 5 (*very unexpected*). We selected the three sources kitchen, bathroom, and nursery for the experiment, because office had large object overlaps with kitchen and nursery. To select objects that are very expected for one source and very unexpected for the other two sources, we chose items with a mean expectancy rating of 4.00 or greater for the expected source and 2.00 or less for the unexpected sources. We chose 48 expected-kitchen items, 48 expected-bathroom items, and 48 expected-nursery items with mean expectancy ratings for the expected source of 4.31 to 4.34 and mean expectancy ratings for the unexpected sources of 1.17 to 1.23.

To match study and test lists on expectancy, we divided each item pool of one type (e.g., expected-nursery items) into two lists (A and B) with 24 items each. Both lists did not differ in mean expectancy ratings.

Procedure. Each experimental session included between one and four participants who were seated in individual computer booths. After giving consent, participants read instructions on the computer screen. No information about the impending source-monitoring test was given. In the study list, each object label appeared above a source label for 4s. Object label and source were written in white capital letters on black background. We used three neutral items as primacy buffer (light bulb, electrical outlet, window), in random order, one with the bathroom source, one with the kitchen source, and one with the nursery source, randomly assigned. After the primacy buffer, 72 item-source pairings (24 expected-bathroom items, 24 expected-kitchen items, 24 expected-nursery items) followed in an order that was randomized by participant. A random half of the items appeared with their expected source; a random quarter appeared with the first unexpected source; and a random quarter appeared with the second unexpected source. The randomization of the source assignment was also by participants. Which item lists (A or B) were presented at study, was counterbalanced.

After study, instructions for the source-monitoring test followed. Six practice items preceded the test items. Three of them were new, one had appeared with the bathroom source, one with the kitchen source, and one with the nursery source. The test included the 72 items shown in the study list and 72 new items (the bathroom, kitchen, and nursery lists that had not been shown at study) and were again presented in white capital letters on black. The order of the test items was randomized by participant.

For each item the question “Which room was this object presented with?” appeared. There were four response options: “bathroom,” “kitchen,” “nursery,” and “neither,” written in colored capital letters. Participants gave their responses by pressing corresponding color-coded keys on the computer keyboard. We marked “D” with a blue sticker, “H” with a yellow sticker, and “L” with a green sticker for the three sources. Color coding was counterbalanced across participants. The space bar was marked with a red sticker and always indicated the “neither” response.

After test, participants made three frequency judgments. They were asked how many of the 24 expected-bathroom items were presented with bathroom, how many of the 24 expected-kitchen items were presented with kitchen, and how many of the 24 expected-nursery items were presented with nursery at study. The order of these three questions was counterbalanced across participants. A demographic questionnaire and the debriefing followed.

Results

We used the two-high-threshold multinomial model of source monitoring for three sources (Keefe et al., 2002; see Appendix B for a figure and description) to separate item memory, source memory, and guessing biases. As in Experiment 1, we combined the data to expected and unexpected item-source pairings. Absolute response frequencies for Experiment 2 are shown in Table A2 in Appendix A. For the multinomial model-based analyses of these data, we used multiTree (Moshagen, 2010). We evaluated model fit with the goodness-of-fit statistic G^2 which is asymptotically chi-square distributed (Hu & Batchelder, 1994). A good model fit is indicated by G^2 values lower than the critical value of G^2. A compromise power analysis ($\alpha = \beta$) with n = 6912 observations, df = 19 and Cohen´s w = .10 suggested an alpha level of .001 and a statistical power of .999.[1] Therefore, we set the alpha level for the goodness-of-fit tests to .001.

We first determined the base model against which we tested our hypotheses. Item memory for items from the expected source, items from both unexpected sources, and new items should be equal ($D_E = D_{U1} = D_{U2} = D_N$), because our manipulation of source memory via use of a single expected source and two unexpected sources should not influence item memory. Furthermore, items were equally likely to appear with any of the sources due to random assignment, and therefore, there should be no differences in memory for items from different sources. In fact, a model that included the above equality restrictions across item-memory parameters showed good fit to the data with $G^2(19) = 17.08$ (critical value of 43.82). A model that additionally included equality restrictions for the source-guessing parameters for recognized versus unrecognized items ($a_E = g_E$, $a_{U1} = g_{U1}$, and $a_{U2} = g_{U2}$), however, showed poor fit to the data with $G^2(22) = 48.92$ (critical value of 48.27), and we, thus, rejected this model. Finally, we included equality restrictions across the unexpected sources in source-memory ($d_{U1} = d_{U2}$), source guessing for recognized items ($a_{U1} = a_{U2}$), and source guessing for unrecognized items ($g_{U1} = g_{U2}$). This model showed good fit to the data with $G^2(22) = 37.90$ (critical value of 48.27). We, thus, used this model with the equality restrictions for the *D* parameters and the equality restrictions across the two unexpected sources as the base model against which we tested hypotheses regarding parameter differences between the expected source and the unexpected sources.

Figure 2 shows source-memory and guessing parameters for the base model. Table 1 shows results of significance tests. We found significantly better source memory for the expected source than for the unexpected sources. In addition, we found stronger guessing towards the expected source than towards each of the unexpected sources, for both recognized and unrecognized items (i.e., $a_E > a_U$, and $g_E > g_U$). We found guessing biases higher than chance (.33) towards the expected source and guessing biases lower than chance towards the unexpected sources. Source guessing for recognized items (Parameter *a*) was base-rate oriented. That is, we found no significant decrease in model fit when setting $a_E = .50$, and when setting $a_U = .25$. By contrast, source guessing for unrecognized items (Parameter *g*) was not base-rate oriented. That is, we found a significant decrease in model fit when setting $g_E =$ .50, and when setting $g_U = .25$.

Frequency judgments were significantly higher than the correct value of 12 with a mean of 14.33 ($SD = 4.53$) for expected-bathroom items, $t(47) = 3.57$, $p < .01$, $d = 0.51$, a mean of 13.81 ($SD = 5.33$) for expected-kitchen items, $t(47) = 2.35$, $p = .02$, $d = 0.33$, and a mean of 13.56 ($SD = 5.28$) for expected-nursery items, $t(47) = 2.05$, $p = .05$, $d = 0.30$.

Discussion

In line with Klauer et al. (2002), we found better source memory for the single expected source compared to the two unexpected sources. With better source memory for the expected source, we were able to investigate if a compensatory guessing bias towards one or both unexpected sources or a schema-based guessing bias towards the expected source occurred. We found no schema-inconsistent guessing bias in either guessing parameter (for recognized and unrecognized items). Thus, the compensatory-guessing hypothesis was not supported. For recognized items, we found a schema-consistent guessing bias reflecting the 50:25:25 contingency in the experiment. For unrecognized items, we found a schema-consistent guessing bias exceeding the true contingency towards more schema-based guessing. In sum, the schema-based guessing hypothesis was supported, whereas the compensatory-guessing hypothesis was not supported. The frequency judgments showed that participants did not correctly recognize the 50:50 ratio of expected to unexpected item-source pairings, but instead showed a bias towards more expected item-source pairings (58%). Thus, schemas influenced the frequency judgments as well.

General discussion

In two source-monitoring experiments, we chose two different manipulations to increase source memory for the expected source in order to test two hypotheses concerning guessing biases against each other. Both manipulations to affect source memory were successful. In Experiment 1, we used longer presentation time for expected than unexpected item-source pairings to increase source memory for the expected source. In line with Meiser et al. (2007), longer presentation times increased source memory. Thus, better source memory for the expected than the unexpected source occurred. In Experiment 2, we used a single expected source and two unexpected sources to increase source memory for the expected source. In line with Klauer et al. (2002), we found better source memory for the single expected source than the two unexpected sources.

With better source memory for the expected source, we were able to investigate guessing biases. If compensatory guessing occurs, better memory for the expected source should lead to schema-inconsistent guessing bias towards the unexpected source(s). By contrast, if schema-based guessing occurs, better source memory for the expected source should lead to schema-consistent guessing bias towards the expected source. In both experiments, we found schema-consistent guessing bias towards the expected source and no schema-inconsistent guessing bias towards the unexpected source(s).

In Experiment 1, comparison of a response condition that included an “I don’t know” response option and a condition that did not include such an option showed significant increase in “expected” responses when the “I don’t know” option was not available. By contrast, comparison of the response conditions revealed no significant increase in “unexpected” responses when the “I don’t know” option was not available. Thus, when participants had to guess the source, because no “I don’t know” response option existed, they guessed the expected source more often than the unexpected source.

A limitation of Experiment 1 is that although participants were instructed to use the “I don’t know” response option when they could not remember the source, effects of guessing on the “expected” und “unexpected” responses may not be completely excluded in this condition. Therefore, we used a multinomial-modeling approach to investigate the same issue in Experiment 2. We found no compensatory guessing bias towards the unexpected sources for either model-based guessing parameter (for recognized and unrecognized items). For recognized items, we found a schema-consistent guessing bias reflecting the true 50:25:25 contingency, and for unrecognized items, we found a schema-consistent guessing bias exceeding the true contingency towards more schema-based guessing. In sum, our results support the schema-based guessing hypothesis, and refute the compensatory-guessing hypothesis.

According to the results of the frequency judgments, participants’ contingency perception was in a schema-consistent direction in both experiments. That is, participants perceived more expected than unexpected item-source pairings, although the true ratio was 50:50 in both experiments.

Although no compensatory guessing occurred in our studies, in studies by Riefer et al. (1994) and Meiser et al. (2007), a compensatory guessing bias towards the less remembered source occurred, when no schema was available and there was a difference in source memory for different sources. In the present experiment, a schema was available, there was a difference in source memory and no compensatory guessing towards the less remembered source occurred. Therefore, we suppose that schematic influences exceed influences of memory differences. Although a memory difference existed, participants guessed in a schema-consistent direction instead of compensating better source memory for expected sources via schema-inconsistent guessing.

At first view, a compensatory guessing strategy seems more reasonable and effective, because the memory advantage for one source is compensated for by guessing the other source. This should lead to quite good overall performance. At second view, however, a schema-based guessing bias could be more reasonable and effective if a schema is available. Our schemas, stereotypes, and other general knowledge result from our everyday experiences, and schema-based guessing is an almost perfect strategy in everyday life. As schema-inconsistent information occurs very rarely, schema-consistent guessing bias will lead to correct responses in almost every case. If someone cannot remember the source of information or information itself, the best strategy is thus schema-based guessing.

Our results of schema-consistent guessing bias instead of compensatory guessing bias imply that "unexpected" responses occur mainly due to memory and "expected" responses due to memory and guessing. Our findings have implications for court testimonies that must be judged regarding their trustworthiness. Our results suggest that an unexpected description of a crime scene or a criminal mainly stems from memory, whereas expected descriptions may stem from memory and schema-based guessing. Thus, unexpected statements are more trustworthy than expected ones.

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Footnotes

[1] We performed power analyses with the G*POWER 3 program (Faul, Erdfelder, Lang, & Buchner, 2007).

[2] We determined which source we labeled "$Unexpected_1$" or "$Unexpected_2$" via separate multinomial analyses for expected-kitchen, expected-bathroom, and expected-nursery items. For each item type, we labeled the unexpected source with higher source-memory and guessing parameter estimates "$Unexpected_1$" and the unexpected source with lower source-memory and guessing parameter estimates "$Unexpected_2$."

Table 1

Results of multinomial model-based analyses of the data from Experiment 2: Parameter estimates, confidence intervals, parameter restrictions, and G^2 *goodness-of-fit values*

	Estimate	Restriction	$\Delta G^2(1)$
D	.59 [.57 - .60]		
b	.30 [.28 - .31]		
d_E	.76 [.72 - .79]	$d_E = d_U$	29.23
d_U	.61 [.58 - .64]		
a_E	.51 [.44 - .58]	$a_E = a_U$	37.25
		$a_E = .33$ (chance)	25.54
		$a_E = .50$ (base rate)	0.06
a_U	.25 [.21 - .28]	$a_U = .33$ (chance)	16.26
		$a_U = .25$ (base rate)	0.04
g_E	.72 [.68 - .76]	$g_E = g_U$	436.10
		$g_E = .33$ (chance)	273.52
		$g_E = .50$ (base rate)	86.27
g_U	.14 [.12 - .16]	$g_U = .33$ (chance)	163.94
		$g_U = .25$ (base rate)	63.07

Note. D = probability of item recognition; b = probability of guessing that an item is old; d_E = probability of remembering the source of an item that had been presented by the expected source; d_U = probability of remembering the source of an item that had been presented by an unexpected source; a_E = probability of guessing that a recognized item had been presented by the expected source; a_U = probability of guessing that a recognized item had been presented by an unexpected source; g_E = probability of guessing that an unrecognized item had been presented by the expected source; g_U = probability of guessing that an unrecognized item had been presented by an unexpected source. 95% confidence intervals are in brackets. $G^2(1)$

values greater than the critical value of 3.84 indicate a significant decrease in model fit with $\alpha = .05$ and, thus, a statistically significant result (critical value of 10.83 for an alpha level of .001).

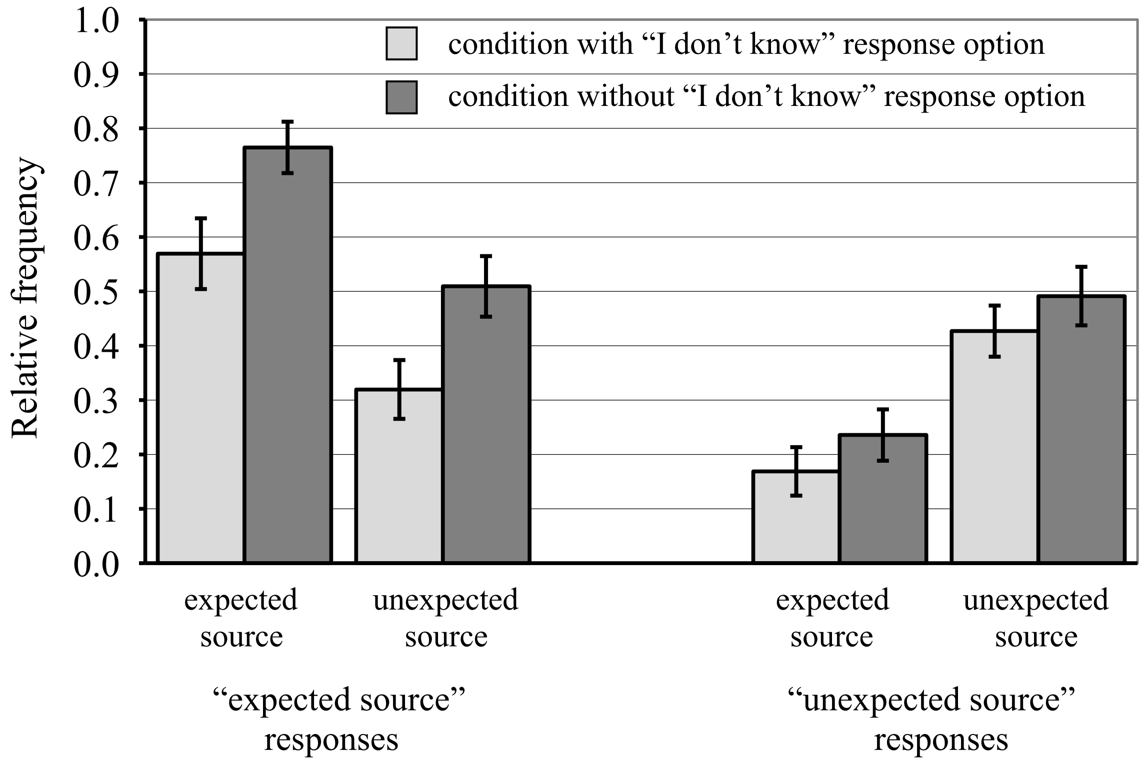

Figure 1. Relative frequency of "expected source" and "unexpected source" responses to items called "old" from the expected source and the unexpected source for both response conditions (Experiment 1). Error bars indicate 95% confidence intervals.

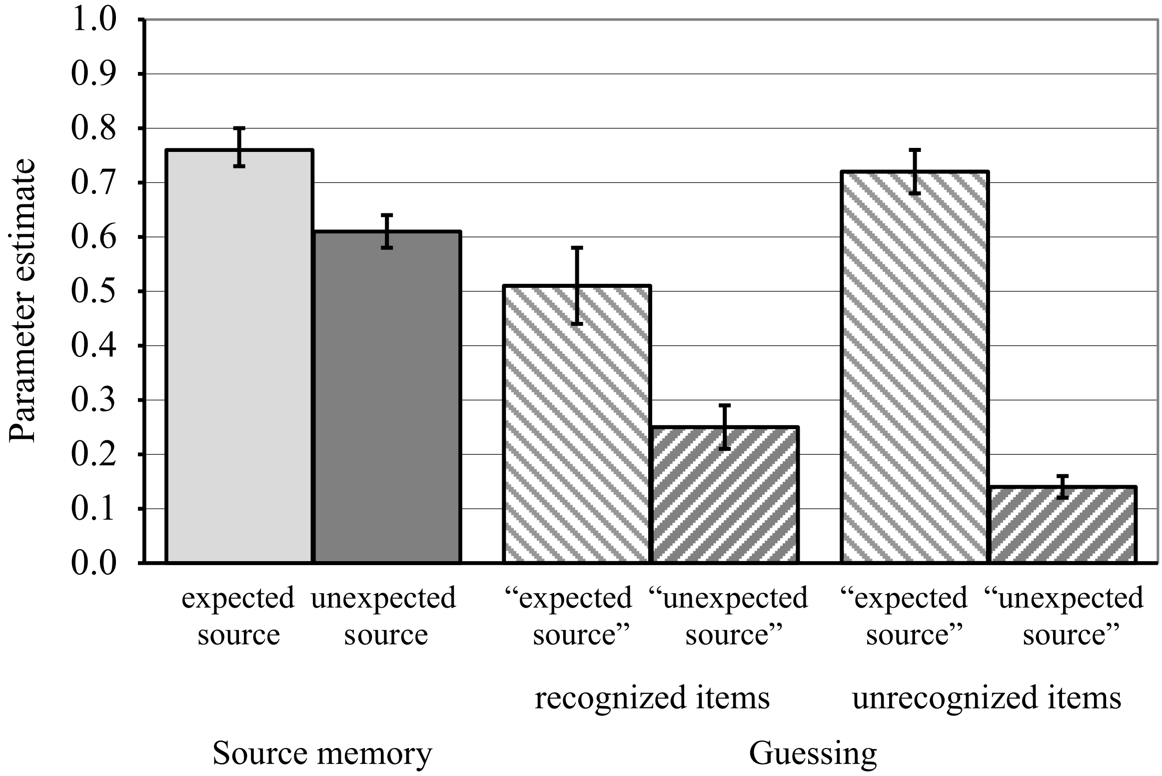

Figure 2. Parameter estimates for source memory and guessing biases as a function of expectancy in Experiment 2. Error bars indicate 95% confidence intervals.

Appendix A: Response frequencies from Experiments 1 and 2

Table A1

Response frequencies for items from the schematically expected source, items from the schematically unexpected source, and new items for both response conditions (Experiment 1)

	”Expected”	”Unexpected”	”I don’t know”	“Neither”
Source	Condition with “I don’t know” response option			
Expected	466	132	195	167
Unexpected	239	311	195	215
New	105	34	59	1722
Source	Condition without “I don’t know” response option			
Expected	579	174	-	207
Unexpected	382	357	-	221
New	133	41	-	1746

Note. Expected = items from the expected source, Unexpected = items from the unexpected source, New = new items. Participant responses are in quotation marks.

Table A2

Response frequencies for items from the schematically expected source, items from the schematically unexpected sources, and new items in Experiment 2

Source	"Expected"	"Unexpected_1"	"Unexpected_2"	"Neither"
Expected	1062	109	73	484
Unexpected_1	160	375	53	277
Unexpected_2	188	72	358	246
New	306	72	47	3031

Note. Expected = items from the expected source, Unexpected_1 = items from the first unexpected source[2], Unexpected_2 = items from the second unexpected source, New = new items. Responses are in quotation marks.

Appendix B: Two-high-threshold multinomial model of source monitoring (2HTSM) for three sources

The 2HTSM for three sources (Keefe et al., 2002; Riefer et al., 1994) is an extension of the 2HTSM for two sources (Bayen et al., 1996). Figure B1 illustrates the model. In the source-monitoring task of Experiment 2, there were one expected and two unexpected sources for each item type. Therefore, an item was either presented with the expected source, the first unexpected source, the second unexpected source, or it was new. There were four response options for each item: “expected source,” “first unexpected source,” “second unexpected source,” and “new.”

The first tree in Figure B1 represents items that had been presented with the expected source; the second tree represents items that had been presented with the first unexpected source; the third tree represents items that had been presented with the second unexpected source; and the fourth tree represents items that were new. The different sources (expected, first unexpected, second unexpected, and new) are indicated by the indices E, U1, U2, and N, respectively.

The item-recognition parameters *D* indicate the probability that participants recognize an item correctly as an old item (D_E, D_{U1}, D_{U2}) or a new item (D_N). With probabilities d_E, d_{U1}, and d_{U2}, participants additionally remember the source of the item. With the complementary probabilities $1 – d_E$, $1 – d_{U1}$, and $1 – d_{U2}$, they do not remember the item’s source and instead guess. With probability a_E, they guess the expected source, with probability a_{U1}, the first unexpected source, and with probability a_{U2}, the second unexpected source. $1 – D_E$, $1 – D_{U1}$, $1 – D_{U2}$, and $1 – D_N$ are the probability that participants do not recognize an item as an old or a new item. In this case, Parameter *b* is the probability that participants guess that the item is old; $1 – b$ is the probability that they guess that the item is new. If participants guess that the item is old (with probability *b*), they must guess the source as well. With probability g_E, they guess the expected source; with probability g_{U1}, the first unexpected source; and with probability g_{U2}, the second unexpected source.

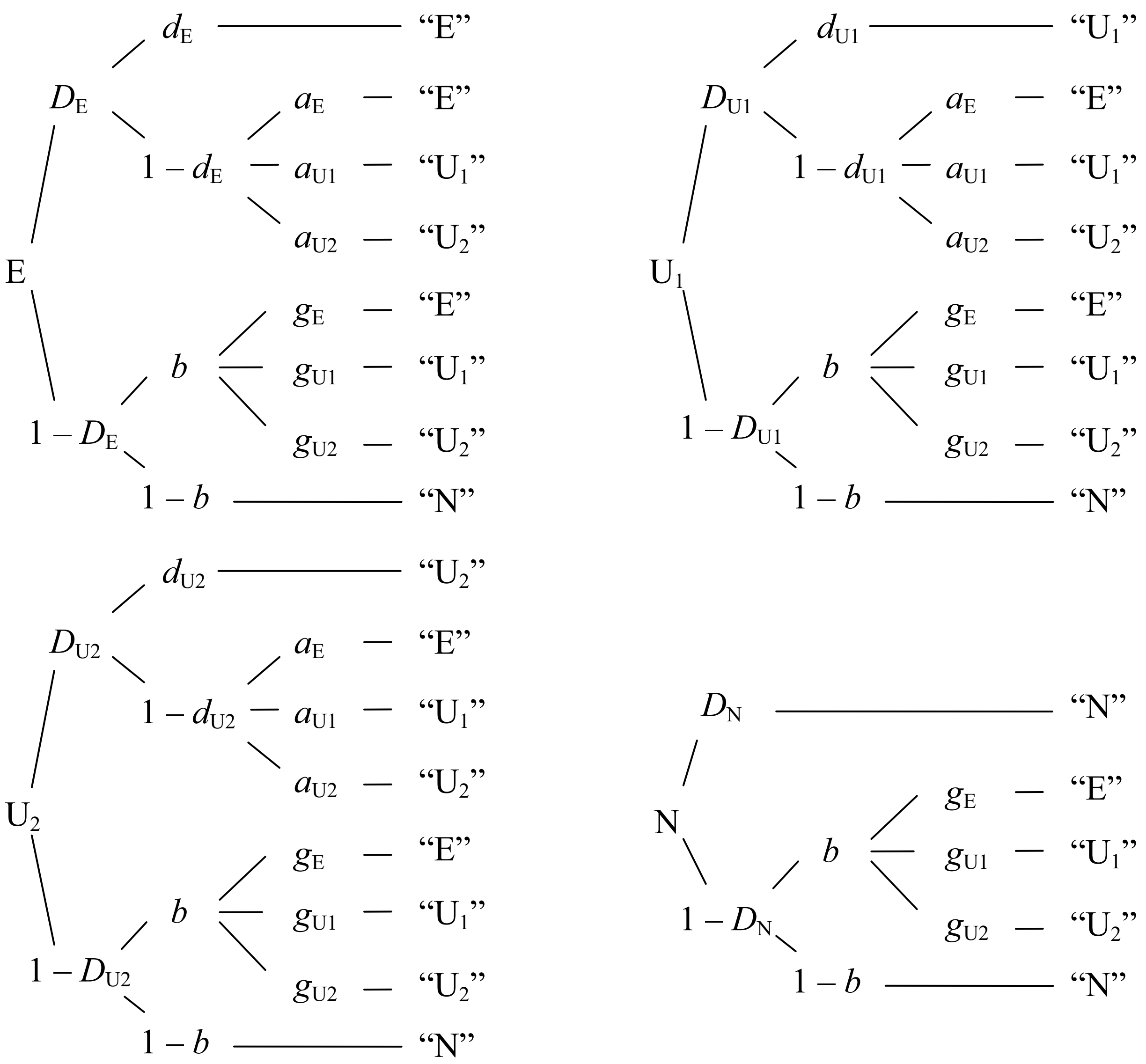

Figure B1. Two-high-threshold multinomial model of source monitoring for three sources. E = item from the expected source; U_1 = item from the first unexpected source; U_2 = item from the second unexpected source; N = new item. Participant responses are in quotation marks. D_E = probability of recognizing an item that had been presented by the expected source; D_{U1} = probability of recognizing an item that had been presented by the first unexpected source; D_{U2} = probability of recognizing an item that had been presented by the second unexpected source; D_N = probability of knowing that a new item is new; d_E = probability of remembering that an item had been presented by the expected source; d_{U1} = probability of remembering that an item had been presented by the first unexpected source; d_{U2} = probability of remembering that an item that had been presented by the second unexpected source; a_E = probability of guessing that a recognized item had been presented by the expected source; a_{U1} = probability of guessing that a recognized item had been presented by the first unexpected source; a_{U2} = probability of guessing that a recognized item had been presented by the second unexpected source; b = probability of guessing that an unrecognized item is old; g_E= probability of guessing that an unrecognized item had been presented by the expected source; g_{U1}= probability of guessing that an unrecognized item had been presented by the first unexpected source; g_{U2}= probability of guessing that an unrecognized item had been presented by the second unexpected source. Adapted from “Response strategies in source monitoring,” by D. M. Riefer, X. Hu, and W. H. Batchelder, 1994, *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20,* p. 686.