No imagination effect on boundary extension

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Abstract Boundary extension (BE) occurs when people falsely remember perceiving beyond the edges of a presented scene. Theorists argue that BE occurs because people mistakenly attribute information they have generated to the study stimulus—that is, they make a source memory error. Inspired by this idea, in six experiments we tested whether scene details resulting from explicit imagination would be misremembered as actual visual perceptions, resulting in increased BE as compared with standard instructions. In four experiments, undergraduates completed a BE task with separate study and test blocks; in two further experiments, undergraduates completed a trial-by-trial BE task ($N = 290$). Half of the participants elaborated on the study pictures (imagined smells and sounds, or what was to the left and right of the scene, or what a photographer would see by zooming in or out). Robust BE was found in all experiments, but none of the elaborations modified the size of BE; therefore, BE is not to be affected by explicit elaboration and may be related to spatial rather than visual imagery ability.

Keywords Boundary extension · Source memory · Spatial imagery

In the present research, we investigated boundary extension (BE) as a type of source memory error. BE occurs when viewers falsely remember seeing a wider angle of a scene than they had actually studied (e.g., Hubbard, Hutchison, &

Courtney, 2010). *Source memory* is the ability to keep track of where information came from (e.g., Johnson, Hashtroudi, & Lindsay, 1993; Lindsay, 2008). For example, sometimes people obtain information from the world, as from a photo, and sometimes they generate it themselves, as when they imagine a scene. These two literatures come together in the multisource view of scene representation (Intraub, 2010; Intraub & Dickinson, 2008), which highlights that individuals can utilize information about scenes from a variety of sources, including visual perception, amodal continuation of surfaces, world knowledge of scene classification, and contextual associations. (Intraub and Dickinson, 2008; see also Intraub, 2010, 2012) argued that BE occurs because people misattribute scene-relevant information that they have generated internally while viewing a picture (or after viewing it) to the picture itself. In short, the argument is that BE is a form of source memory error.

Although BE is often studied with visual stimuli, BE also has been observed following blindfolded, haptic explorations of tabletop scenes (Intraub, 2004). Specifically, when participants used both hands to explore a tabletop scene involving three to five objects and were then asked to adjust a surrounding wooden frame, they made the frame larger than the original (Intraub, 2004). The act of physically exploring the objects with their hands and then adjusting the frame led to BE, highlighting the cross-modal aspect of multisource scene representation (Intraub, 2010, 2012). Both visual and haptic exploration have shown BE, which Intraub (2010, 2012) sees as evidence that multiple sources of information are used to create a larger representation of the scene.

In the present research, we assessed whether participants' imagination of sensory details affects BE, since this manipulation affects other source memory errors. Thomas, Bulevich, and Loftus (2003), for example, demonstrated that the elaboration of sensory details during study increases source

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memory errors at test. More specifically, Thomas et al. asked participants to identify which simple actions they had actually performed at study and which actions they had only imagined. As compared with participants who engaged in simple imagining (e.g., *Imagine kissing the frog.*), participants who engaged in elaborate imagining (e.g., *Imagine kissing the frog. Imagine the color of the frog. Imagine the feel of the frog against your lips.*) showed increased false “did” responses, incorrectly claiming they had performed actions they had elaborately imagined. This was true when the visual and sensory details were provided by the researchers, and when the details were participant-generated. In the present series of experiments, we asked participants to view photographs and elaborate on scenes cross-modally (what smells and sounds would occur, Exps. 1a–2b) or visually (what was to the left and right of the picture, Exp. 3a; what the photographer would see by zooming in or out, Exp. 3b). We expected the elaboration conditions to lead to richer scene representations, and more BE, in parallel with the elaborate imagination conditions leading to increased source memory errors for actions (Thomas et al. 2003).

Prior evidence had suggested that instructions to imagine additional spatial information can influence BE (Intraub, Gottesman, & Bills, 1998). Participants shown outlines of central objects and instructed to imagine specific spatial backgrounds exhibited BE, whereas those instructed to imagine object color did not. In addition, more BE was observed when participants were shown line drawings than when they were shown photographs (Gagnier & Intraub, 2012). Gagnier and Intraub’s results suggest that photographs may be the best kind of stimuli to begin exploring enhancement of BE, because line drawings could already produce BE at ceiling. Thus, in the present series of experiments we used photographs as the stimuli and asked participants to imagine additional sensory details. The typical scenes used in BE experiments tend to have fairly isolated, central objects, but to encourage rich elaborations, for five of the present experiments we used scenes with multiple items (see Fig. 1).

Notably, imagination per se does not always increase source memory errors (Foley, Foy, Schlemmer, & Belser-Ehrlich, 2010). Using the Deese-Roediger–McDermott paradigm with participants asked to remember lists of pictures or words, Foley et al. (2010) found reduced errors when participants were instructed to deliberately generate images of pictures or words. They suggested that the act of generating the images distinguished these items from the actual list items, and thus reduced source memory errors. Foley (2012) highlighted a distinction between spontaneous imagery and intentional self-generated imagery; the present research included both, and we will return to this distinction in the General Discussion. To the extent that scene representation, as measure by BE, is related to imagining isolated objects (the

task in Foley et al. 2010), additional imagery instructions might *reduce* BE.

Just as experimental manipulations have affected source memory performance, so individual-difference variables have as well. For example, Markham and Hynes (1993) compared the source memory performance of undergraduates who self-reported high vividness of visual imagery with that of counterparts who reported low vividness. The control participants saw geometric shapes and rated their complexity; the experimental participants imagined stimuli that were half shapes as being symmetrically completed around an axis. At test, all participants identified geometric forms as having been whole or half shapes during study. The participants with high self-reported vividness of visual imagery made source memory errors, confusing the imagined and perceived geometric shapes, more than the other groups did. Thus, these data suggest that people high in visual imagery may find it particularly difficult to discriminate between what they had generated and what had been presented to them (see also Finke, Johnson, & Shyi, 1988).

In four of the present experiments, we assessed participants’ visual imagery and correlated those scores with their BE scores. On the basis of Markham and Hynes (1993), one might expect that participants high in visual imagery would have more trouble than participants low in visual imagery in discriminating information they had generated from what had been presented to them, leading to a positive correlation between visual imagery ability and BE scores. In tentative support of this, Mullally, Intraub, and Maguire (2012) found that amnesic patients had lower scores than controls on a “scene probe” task that assessed their ability to imagine beyond the borders of a presented photograph. In addition, the amnesic patients had attenuated BE. Although the authors interpreted their results specifically in terms of scene structure, the results also suggest that a lack of imagery ability might impact other cognitive tasks. Specifically, for the present discussion, the findings that amnesics had lower imagining abilities and less BE than controls is correlational evidence that lack of ability to imagine beyond a scene’s borders is associated with reduced BE. Stated another way, participants low in visual imagery may have low BE scores; that is, there may be a positive correlation between imagery and BE.

In the present experiments, a given picture could be shown as a close-up (C) or a wide-angle shot (W) at study and at test (e.g., *CW* indicates close-up at study and wide-angle at test; *CC* indicates close-up at both study and test—i.e., an identical view). For each experiment, there were three critical analyses, the first two involving replication of typical BE results, and the last asking whether instructions during the study block affected the BE results. First, how would participants rate identical pictures (CC, WW)? Importantly, rating an identical photograph as being closer indicates BE for the original view. Previous work has revealed more BE (i.e., more extreme

Fig. 1 Example photographs of cities, markets, deserts, and forests from the world set used in Experiments 1a, 1b, 2a, 3a, and 3b: (A) Close-up and (B) wide-angle views

“closer” ratings) for close-up than for wide-angle views (e.g., Intraub & Dickinson, 2008), but the most important pattern for both CC and WW is significant negative (“closer”) ratings, even though the correct response is “the same.” Second, would participants notice the “different” trials (CW, WC) equally, or would they mistake CW trials as being identical, indicating extension at study, while viewing WC as being quite different? Typical BE results show smaller ratings for CW than for WC trials, with CW trials sometimes showing positive rather than negative ratings (e.g., Intraub & Dickinson, 2008). Finally, would the instruction set (elaboration vs. standard conditions) influence either the “same” trials (CC, WW) or “different” trials (CW, WC)? To assess these three questions, we followed the analysis used in other BE work (e.g., Dickinson & Intraub, 2008) and conducted two mixed-design analyses of variance (ANOVAs), 2 (Same Angles) $\times$ 2 (Instruction Set) and 2 (Different Angles) $\times$ 2

(Instruction Set), for each experiment. We also used two different experimental designs, one with instruction set between participants involving a study block followed by a test block (Exps. 1a, 1b, 3a, and 3b, similar to the design of Gagnier & Intraub, 2012), and a within-participants design with multiple pictures in a trial, testing one immediately (Exps. 2a and 2b), in which participants were given imagery instructions in a second block (similar to the design of Dickinson & Intraub, 2008).

The use of multiple methodologies allowed us to assess any effects of instructions on BE in a range of contexts. We expected to find (a) significant BE in both CC and WW conditions, (b) significantly greater BE in WC than in CW conditions, and (c) significantly greater BE with elaboration instructions than with standard instructions. Finally, in the experiments that included imagery measures, we expected to see a positive correlation between imagery and BE.

Experiments 1a and 1b

Photographs of scenes (both close-up and wide-angle views) were presented, and participants were either given standard instructions or prompted to imagine sounds and odors that would accompany each scene. At test, the photographs were either the same as (CC, WW trials) or different from (CW, WC trials) the ones given at study, and participants rated whether the test photograph was closer, the same, or farther away, on a 5-point scale (Intraub & Richardson, 1989). Importantly, rating an identical photograph as closer would indicate BE for the original view. Of interest was whether imagining additional details would increase BE, as participants confused imagined with experienced details. In Experiment 1a, participants studied each photograph for 6 s during the first block, and Experiment 1b photographs were presented for 15 s of study.

In addition to manipulating the instructional sets (standard vs. elaboration), Experiment 1b also included the Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973), which assesses pictorial imagery. Marks had participants study photographs and, following a distraction task, asked multiple-choice questions to assess picture memory (e.g., “Was the ballerina standing: *on tiptoes, with one foot on the floor, or with both feet on the floor?*,” p. 19). He found more accurate picture memory for participants with higher VVIQ scores (self-reported experiencing of more vivid images). A parallel result would be a negative correlation between VVIQ and BE, with higher VVIQ scores corresponding to more accurate memory (less or no BE); however, more recent work has suggested that higher VVIQ scores instead correspond with increased BE (Markham & Hynes, 1993; Mullally et al. 2012).

Method

Participants

Undergraduates participated in either Experiment 1a ($n = 67$; 40 women, 27 men) or 1b ($n = 58$; 37 women, 21 men) as one option to earn course credit.

Materials

The stimuli were 48 photographs: 12 each of city scenes, outdoor market scenes, desert scenes, and forested scenes from various locations around the world. There were two versions of each picture: a wide-angle view, as well as a close-up that was either 10 %, 15 %, or 20 % enlarged and then cropped to the same size as the original (720×480 pixels). Dickinson and Intraub (2008) had close-up views that were 8 %–21 % enlargements of the wide-angle views. Both the wide-angle and close-up versions were the same size, but more background was visible in the wide-angle versions (see Fig. 1 for

examples). All of the pictures were in landscape orientation and were presented centered on a black screen.

Experiment 1b included the VVIQ (Marks, 1973), which assesses pictorial imagery. Each of four scenes (a friend or relative, the rising sun, the front of a shop, and a country scene) was to be imagined once with the participant’s eyes open and once with the eyes closed. Participants rated the vividness of each mental image on a 5-point scale (1 = *Perfectly clear and as vivid as normal vision*, 5 = *No image at all, you only “know” that you are thinking of an object*; Marks, 1973, p. 24); note that *lower* scores indicate superior visual imagery.

Apparatus

Experiment 1a was run on a Dell Optiplex 9020 computer ($1,280 \times 1024$ screen resolution). In Experiment 1b we used a 21-in. iMac display ($1,920 \times 1,080$ screen resolution). In both experiments, the stimuli were presented by and responses were collected using SuperLab (Cedrus).

Design

Experiments 1a and 1b were based on a 4 (Trial Type: CC, WW, CW, WC) $\times$ 2 (Condition: standard, elaboration) mixed-factor design with Condition as the between-participants factor.

Procedure

Participants viewed each study photograph for either 6 s (Exp. 1a) or 15 s (Exp. 1b). The opening instructions asked participants to try to remember as much detail as possible, including the background of the photograph. In the standard condition for both Experiments 1a and 1b, participants initially viewed a photograph without additional instructions. Text then appeared above the photograph to indicate that the participants had 4 s (Exp. 1a) or 10 s (Exp. 1b) left to study it, followed by text appearing below the photograph to indicate that participants had 2 s (Exp. 1a) or 5 s (Exp. 1b) left to study.

Participants in the experimental conditions in both Experiments 1a and 1b received additional elaboration instructions to imagine sounds and odors that might be part of the scene, suggesting that this might help their memory. Instead of text indicating the remaining time, text appeared above each photograph asking participants to imagine sounds after 2 s (Exp. 1a) or 5 s (Exp. 1b), followed by text appearing below the photograph asking participants to imagine odors when 2 s (Exp. 1a) or 5 s (Exp. 1b) of study remained. The photographs were counterbalanced across participants, such that each version (close-up or wide-angle) appeared as a study picture.

For both experiments, immediately after the study phase, the test phase began. Instructions indicated that the next photographs would be the same or would be similar to the ones just shown, and that the task was to decide whether each photograph was taken from the same camera position as the version seen earlier, or whether the camera was a little (or a lot) closer or farther away. Participants were then shown an example study photograph with test photographs that were labeled *a lot closer*, *a little closer*, *a little farther away*, and *a lot farther away*. After any questions were addressed, participants saw test photographs and categorized each one using a 5-point scale [*a lot closer* (−2), *a little closer* (−1), *the same* (0), *a little farther away* (+1), and *a lot farther away* (+2)] to indicate any changes relative to the version they had seen at study, using virtual onscreen buttons for mouse responses. Participants also indicated their confidence as being *sure*, *pretty sure*, *not sure*, or *did not see the picture*. In Experiment 1b, participants were then escorted to a different room, and the VVIQ was administered by a research assistant who read the questions and recorded participants' verbal responses. The VVIQ was always administered after the BE task, to avoid suggesting that participants should use imagery in the standard-instruction condition.

Results

Confidence ratings

Participants were confident in their ratings: for the 6 s (Exp. 1a) elaboration instructions, they reported being *sure*, *pretty sure*, and *not sure* 28 %, 51 %, and 17 %, respectively; for the standard instructions, these responses were 32 %, 47 %, and 18 %, respectively. Participants

indicated that they did not remember the picture 4 % of the time under both the elaboration and standard instructions. For the 15-s condition (Exp. 1b), the elaboration instruction participants were *sure*, *pretty sure*, and *not sure* 34 %, 46 %, and 17 % of the time; for the standard instruction participants, these values were 34 %, 45 %, and 16 %, respectively. The participants in Experiment 1b chose *did not see picture* 2 % with elaboration, and 6 % with standard, instructions.

BE scores

The mean boundary ratings and 95 % confidence intervals are presented in Fig. 2. For both experiments, in the first of the three critical comparisons, significant negative ratings for both the CC and WW trials indicate BE for both types of “same” trials. Second, participants gave larger ratings to WC than to CW trials. Third, there was no effect of instruction condition (“sound and odor” vs. standard) in either experiment.

Experiment 1a (6-s study phase) For the “same” trials, a 2 (Trial Type: CC, WW) × 2 (Instruction Set: standard, elaboration) mixed-design ANOVA showed a marginal main effect of trial type, $F(1, 65) = 3.46$, $p = .07$, $\eta^2 = .05$, indicating similar BE for CC and WW trials, with a trend toward more BE in CC than in WW. We observed no main effect of instructions, $F(1, 65) = 2.39$, $p = .13$, $\eta^2 = .04$, nor an interaction, $F(1, 65) < 1$. For “different” trials, a 2 (Trial Type: CW, WC) × 2 (Instruction Set: standard, elaboration) mixed-design ANOVA revealed a main effect of trial type, $F(1, 65) = 69.11$, $p < .001$, $\eta^2 = .51$, indicating that participants gave larger ratings to WC changes from study to test than they gave to CW changes, replicating previous work (e.g., Dickinson & Intraub, 2008).

Fig. 2 Mean boundary ratings for the standard and elaboration conditions in Experiments 1a (A) and 1b (B). The experimental group was asked to imagine sounds one might hear and odors one might smell for a scene. (A) Study time at 6 s for the standard and elaboration conditions. (B) Study time at 15 s for the standard and elaboration

conditions. Negative ratings indicate that the test scene appeared to be closer than the original, and ratings of 0 indicate that the test scene appeared identical to the original. Error bars indicate 95 % confidence intervals of the means. C = close-up, W = wide-angle

No main effect of instructions emerged, $F(1, 65) < 1$, nor an interaction, $F(1, 65) = 1.40$, $p = .24$, $\eta^2 = .01$.

Experiment 1b (15-s study phase) For the “same” trials, a 2 (Trial Type: CC, WW) $\times$ 2 (Instruction Set: standard, elaboration) mixed-design ANOVA revealed a main effect for trial type, $F(1, 56) = 8.78$, $p = .004$, $\eta^2 = .13$, indicating stronger BE for CC than for WW trials. No main effect of instructions was apparent, $F(1, 56) = 1.73$, $p = .19$, $\eta^2 = .03$, nor an interaction, $F(1, 56) = 2.55$, $p = .12$, $\eta^2 = .04$. For “different” trials, a 2 (Trial Type: CW, WC) $\times$ 2 (Instruction Set: standard, elaboration) mixed-design ANOVA revealed a main effect of trial type, $F(1, 56) = 70.99$, $p < .001$, $\eta^2 = .56$, indicating that participants gave larger ratings to WC changes from study to test than they gave to CW changes, replicating previous work (e.g., Dickinson & Intraub, 2008). There was no main effect of instructions, $F(1, 56) < 1$, nor an interaction, $F(1, 56) < 1$.

Pictorial imagery

We found individual differences in self-reported imagery ability in Experiment 1b: There was a significant difference between the top ($M = 1.67$, $SD = 0.24$) and bottom ($M = 3.13$, $SD = 0.43$) quartiles for the VVIQ scores, $t(26) = 11.12$, $p < .001$, $d = 4.20$. However, we found no difference between the CC scores for those in the top ($M = -0.42$, $SD = 0.39$) and bottom ($M = -0.21$, $SD = 0.27$) quartiles of the VVIQ scores, $t(26) = 1.68$, $p = .10$, $d = 0.63$. In other words, participants who self-reported having strong visual imagery had only marginally greater (more negative) BE than those who self-reported poor pictorial imagery. Further emphasizing the lack of a link between pictorial imagery ability and BE, we observed no significant correlation between VVIQ scores and the CC test condition (since CC is thought to be the most sensitive test of BE; see Intraub, Daniels, Horowitz, & Wolfe, 2008), $r(57) = .16$, n.s.

Discussion

BE was observed in both angle sizes of “same” trials (CC and WW), with the typical pattern of more BE for CC trials being observed with longer presentation times at study (Exp. 1b, 15 s). In addition, participants gave larger ratings to WC trials than to CW trials, though they rated even CW trials as being closer, suggesting that this picture set led to strong BE. We did not find a significant relationship between self-reported visual imagery and BE scores.

Participants instructed to imagine additional information—specifically, sounds and odors—did show significant BE across “same” and “different” trials. However, the BE ratings following elaboration instructions were equivalent to those after standard instructions. Unlike memory for actions (Thomas et al. 2003), there was not an inflation of memory

errors following more elaborate encoding for BE. We also found no reduction of BE, as had been observed for imagined objects (Foley et al. 2010), suggesting that memory was not improved by the act of imagining additional details.

One possible objection to Experiments 1a and 1b is that the photographs used in them were not typical of BE studies, which feature pictures with a single object on a continuous background. We originally chose the more complicated, multi-object scenes in order to facilitate imagining additional information, but it is important to examine whether an imagination inflation effect would be possible with simpler scenes. Perhaps in the same way that simpler line drawings lead to greater BE than do photographs (Gagnier & Intraub, 2012), simpler photographs might allow for more of an imagination effect.

Experiments 2a and 2b

As was noted in the introduction, our goal was to examine as thoroughly as possible whether explicit imagination can influence BE by using both types of BE methods across our experiments. Thus, Experiments 2a and 2b also involved a different method, in which a series of pictures was presented followed by an immediate memory test using one of the pictures, similar to the design of Dickinson and Intraub (2008). The first block presented standard instructions, and a second block presented elaboration instructions to imagine sounds and odors; this within-participants design also increased the range of conditions under which we explored the relationship between imagination and BE.

Furthermore, in Experiment 2b we used a new set of photographs, each featuring a single central object (see Fig. 3). The instructions asked participants to imagine how traffic sounds, food tastes, and animals smelled.

Finally, due to mixed reports regarding satisfactory test-retest reliability for the VVIQ (McAvinue & Robertson, 2007), we adopted a new measure of visual imagery: All participants completed the session by taking the Object–Spatial Imagery Questionnaire (OSIQ; Blajenkova, Kozhevnikov, & Motes, 2006), which consists of questions that reliably distinguish object imagery (representations of color and individual objects) from spatial imagery (representations of schematic images and spatial relations between objects).

Method

Participants

Undergraduates participated in either Experiment 2a ($n = 15$; 9 women, 6 men) or 2b ($n = 31$; 18 women, 13 men), both of which had within-participants designs, as one option to earn course credit.

Fig. 3 Schematic of a trial sequence during the imagery block for Experiment 2b, using photographs from our typical set. The actual stimuli did not fill the entire screen, and all images and instructions were centered on a black background

Materials

Experiment 2a was based on the same photographs as Experiment 1. New photographs were taken for Experiment 2b, each featuring a single, central object featuring a single piece of fruit, animal, or traffic sign (eight in each category; see Fig. 3). There were two versions of each picture: a wide-angle view, and a close-up that was either 10 %, 15 %, or 20 % enlarged and then cropped to the same size as the original (720×480 pixels). As we noted earlier, Dickinson and Intraub (2008) had close-up views that enlarged wide-angle views from 8 % to 21 %. Both the wide-angle and close-up versions were the same size, but more background was visible in the wide-angle versions. All of the pictures were in landscape orientation and were presented centered on a black screen.

Both Experiments 2a and 2b included the OSIQ (Blajenkova et al. 2006), which consists of 30 intermixed questions, 15 measuring object imagery (representations of color and individual objects) and 15 measuring spatial imagery (representations of schematic images and spatial relations between objects). Participants responded on a 5-point scale (1 = *totally disagree*, 5 = *totally agree*); note that *higher* scores indicate superior visual imagery ability.

Design

Experiments 2a and 2b featured 4 (Trial Type: CC, WW, CW, WC) $\times$ 2 (Instructions: standard, elaboration) within-participants designs.

Procedure

Participants were tested individually with the same equipment as in Experiment 1b. Unlike the blocked procedure used in Experiments 1a and 1b, Experiments 2a and 2b used a rapid serial visual presentation (RSVP) procedure (see Fig. 3 for an Experiment 2b RSVP series of events). Initial instructions explained that participants would see a sequence of pictures and highlighted the importance of remembering the entire picture, including the background. The instructions included an example study photograph with test photographs that were labeled *a lot closer*, *a little closer*, *a little farther away*, and *a lot farther away*. Each trial consisted of an RSVP sequence (Exp. 2a: 4 s/photograph, four photographs per RSVP; Exp. 2b: 5 s/photograph, three photographs per RSVP). Following the last picture, four smiley faces were presented in sequence (500 ms/smiley, total of 2,000 ms) as a mask, and then one of the study pictures was tested (see Fig. 3). The smiley faces were centered on a random mask and filled approximately 8 %

of the total area (see Fig. 3). Participants rated position and confidence as in Experiments 1a and 1b. Each RSVP sequence was repeated (Exp. 2a, eight times; Exp. 2b, six times), so that each picture was included in a “same” trial (CC or WW) and a “different” trial (CW or WC). Experiment 2a included 96 trials, and Experiment 2b included 48 trials. Nothing about the RSVP sequence indicated which picture would be tested, and there were equal numbers of the study–test conditions (CC, WW, CW, WC) across the sequences.

All participants began with standard BE instructions. After the first block (Exp. 2a, 48 trials; Exp. 2b, 24 trials), new instructions appeared explaining that to help with the memory task, participants should now try to imagine additional details. The Experiment 2a imagery instructions prompted participants to imagine sounds and odors (like those in Exps. 1a and 1b). Experiment 2b asked how the fruit would taste, how the animal would smell, and how the surrounding traffic would sound. These elaboration instructions were repeated before each trial. A different set of pictures was used in each block, and between participants the sets were counterbalanced so that both sets were used in the standard block and the elaboration block. Trials were presented in a unique random order for each participant.

Following the BE trials, the final block of the experiment was the OSIQ, with participants indicating their agreement to each statement using the keypad. The order of the blocks was fixed to avoid suggesting that participants use of imagery during the standard-instruction condition for the BE task.

Results

Confidence ratings

Participants were confident in their ratings: For the world set of pictures (Exp. 2a: 4 s/photograph, four photographs per RSVP) with elaboration instructions, participants reported being *sure*, *pretty sure*, and *not sure* 43 %, 44 %, and 13 %, respectively; for the standard-instruction, these responses were 43 %, 42 %, and 14 %, respectively. Participants indicated that they did not remember the picture on 1 % of trials under elaboration instructions, and they never did not remember under standard instructions. For the typical set of pictures (Exp. 2b: 5 s/photograph, three photographs per RSVP) with elaboration instructions, participants were also confident, with *sure*, *pretty sure*, and *not sure* responses on 49 %, 41 %, and 9 % of trials; for the standard instructions, these values were 52 %, 40 %, and 8 %, respectively. Participants chose *did not see picture* on less than 1 % of trials in both the elaboration and standard conditions.

BE scores

The mean boundary ratings and 95 % confidence intervals are presented in Fig. 4. For both experiments, in the first of the three critical comparisons, significant negative ratings for both CC and WW trials indicated BE for both types of “same” trials. Second, participants gave larger ratings to WC than to CW trials. Third, we found no effect of instruction condition (Exp. 2a, “sound and odor”; Exp. 2b, “taste, odor, and sound,” compared with standard) in either experiment.

Fig. 4 Mean boundary ratings for the standard and elaboration conditions in Experiments 2a (A) and 2b (B). All participants began with standard conditions, and in a second block were asked to (A) imagine sounds and odors for the world-picture set, or (B) imagine taste, odor, and sounds for the typical-picture set. Negative ratings

indicate that the test scene appeared to be closer than the original, and ratings of 0 indicate that the test scene appeared identical to the original. Error bars indicate 95 % confidence intervals of the means. C = close-up, W = wide-angle

Experiment 2a (world pictures, 4 s/photograph, four photographs per RSVP) For the “same” trials, a 2 (Trial Type: CC, WW) $\times$ 2 (Instruction Set: standard, elaboration) within-participants ANOVA revealed no main effect of trial type, $F(1, 14) < 1$, indicating equivalent BE for CC and WW trials; no main effect of instructions, $F(1, 14) < 1$; and no interaction, $F(1, 14) < 1$. For “different” trials, a 2 (Trial Type: CW, WC) $\times$ 2 (Instruction Set: standard, elaboration) within-participants ANOVA revealed a main effect of trial type, $F(1, 14) = 11.36, p < .01, \eta^2 = .21$, indicating that participants gave larger ratings to WC changes than to CW changes from study to test, replicating previous work (e.g., Dickinson & Intraub, 2008); no main effect of instructions, $F(1, 14) < 1$; and no interaction, $F(1, 14) = 1.64, p = .22, \eta^2 = .01$. Note that the absolute values of the WC scores were used in the ANOVA, in order to compare participants’ use of the scale (Dickinson & Intraub, 2008).

Experiment 2b (typical pictures, 5 s/photograph, three photographs per RSVP) For the “same” trials, a 2 (Trial Type: CC, WW) $\times$ 2 (Instruction Set: standard, elaboration) within-participants ANOVA revealed no main effect of trial type, $F(1, 30) = 2.71, p = .11, \eta^2 = .04$, indicating equivalent BE for CC and WW trials. We observed no main effect of instructions, $F(1, 30) = 2.09, p = .16, \eta^2 = .01$, and no interaction, $F(1, 30) = 2.22, p = .15, \eta^2 = .02$. For “different” trials, a 2 (Trial Type: CW, WC) $\times$ 2 (Instruction Set: standard, elaboration) within-participants ANOVA revealed a main effect of trial type, $F(1, 30) = 50.30, p < .001, \eta^2 = .39$, indicating that participants gave larger ratings to WC changes than to CW from study to test, replicating previous work (e.g., Dickinson & Intraub, 2008). No main effect of instructions was apparent, $F(1, 30) = 1.90, p = .18, \eta^2 = .00$, and no interaction, $F(1, 30) < 1$. Note that the absolute values of the WC scores were used in the ANOVA, in order to compare participants’ use of the scale (Dickinson & Intraub, 2008).

Object and spatial imagery

We found individual differences in self-reported imagery ability in both experiments, with a significant difference between the top and bottom quartiles for the OSIQ object imagery and spatial imagery scores (see Table 1). In Experiment 2a (world pictures, 4 s/photograph, four photographs per RSVP), the top and bottom quartiles for object imagery were statistically different, $t(6) = 5.95, p < .01, d = 4.21$; the same pattern held for spatial imagery, $t(6) = 15.39, p < .001, d = 10.89$. Experiment 2b (typical pictures, 5 s/photograph, three photographs per RSVP) replicated that pattern: $t(14) = 10.02, p < .001, d = 5.01$, and $t(14) = 11.91, p < .001, d = 5.95$, for object and spatial imagery, respectively. However, we observed no difference between the CC scores for those in the top and bottom quartiles of the OSIQ subscale in either Experiment 2a or 2b,

Table 1 Mean (with *SD*) scores on the Object–Spatial Imagery Questionnaire (OSIQ) for the top and bottom quartiles, calculated separately for the object and spatial imagery measures

Quartile	OSIQ Measure	
	Object Imagery	Spatial Imagery
Experiment 2a (World Pictures)		
Top	3.83 (0.18)	3.42 (0.15)
Bottom	2.45 (0.43)	2.10 (0.09)
Experiment 2b (Typical Pictures)		
Top	3.99 (0.28)	3.52 (0.26)
Bottom	2.52 (0.30)	1.97 (0.26)
Experiment 3a (World Pictures)		
Top	4.04 (0.18)	3.45 (0.27)
Bottom	2.87 (0.26)	2.22 (0.24)

Quartiles are calculated separately for object and spatial imagery (1 = *totally disagree*, 5 = *totally agree*), with higher scores representing higher self-reported imagery. Bold means indicate that the top and bottom quartiles were significantly different (see the text for the statistical details of each comparison).

all t s < 1.55 , n.s. (see Table 2 for the BE scores). In other words, participants who self-reported having strong object imagery or spatial imagery had BE equivalent to those who self-reported poor object imagery or spatial imagery. Further emphasizing the lack of a link between self-reported visual imagery ability and BE, there were no significant correlations (r s between $-.46$ and $.36$, n.s.) between OSIQ scores and any of the CC conditions (since CC is thought to be the most sensitive test of BE; see Intraub et al. 2008).

Discussion

BE was observed in all CC trials, standard and elaboration, and for WW trials in the standard condition. When participants rated WW trials following elaboration instructions, no BE was observed (see Fig. 4). Participants again gave larger ratings to WC than to CW trials, and using the RSVP method of testing BE, they correctly identified that CW trials contained wider images (positive scores). We found no relationship between self-reported visual imagery and BE scores.

Two interesting patterns have emerged from Experiments 2a (world pictures, 4 s/photograph, four photographs per RSVP stream) and 2b (typical pictures, 5 s/photograph, three photographs per RSVP stream) concerning stimuli and method. First, visual inspection of Fig. 4 reveals practically identical patterns for the BE ratings of the world set of photographs and the more typical, single-item set of photographs. This strengthens our confidence that the data patterns reported in Experiments 1a, 1b, and 2a are not unique to relatively complicated scenes. Second, participants correctly noticed that the CW pictures were actually wider (see the positive ratings in

Table 2 Mean (with *SD*) boundary extension (BE) scores for the top and bottom quartiles of Object–Spatial Imagery Questionnaire (OSIQ) measures

Quartile	OSIQ Factor			
	Object Imagery		Spatial Imagery	
	CC Standard	CC Elaboration	CC Standard	CC Elaboration
Experiment 2a (World Pictures)				
Top	−0.33 (0.22)	−0.10 (0.11)	−0.23 (0.22)	−0.10 (0.33)
Bottom	−0.10 (0.21)	−0.25 (0.26)	−0.27 (0.25)	−0.33 (0.22)
Experiment 2b (Typical Pictures)				
Top	−0.12 (0.20)	−0.14 (0.32)	−0.33 (0.31)	−0.27 (0.40)
Bottom	−0.25 (0.43)	−0.44 (0.43)	−0.12 (0.21)	−0.27 (0.34)

BE scores were sorted by each OSIQ factor; negative scores indicates BE. No differences in BE scores were observed based on OSIQ factors. CC, close-up stimuli at both study and test

Fig. 4) when the RSVP method was used. However, participants still gave larger ratings to the WC condition, shown in the more extreme ratings than in the CW condition, replicating previous work (e.g., Dickinson & Intraub, 2008).

Experiments 3a and 3b

After failing to find an effect on BE from cross-modal elaboration (e.g., “imagine the sounds and smells related to what is presented visually”), we attempted to detect it using visual elaboration. Specifically, we asked participants to imagine what might be to the left or right of a scene (Exp. 3a) or to zoom in or out of a picture, much as a photographer can (Exp. 3b; see Fig. 5 for examples), to see whether visual elaboration affects BE. Intraub (2012) discusses the modality of the input (vision vs. haptics) being the key to the amount of boundary extension, with larger BE being supported by visual exploration of a scene. The present experiments returned to the methods of Experiment 1b, but now we instructed participants to imagine additional visual information.

Method

Participants

Undergraduates participated in either Experiment 3a ($n = 70$; 39 women, 31 men) or 3b ($n = 49$; 35 women, 14 men) as one option to earn course credit.

Materials

The same picture stimuli from Experiments 1a, 1b, and 2a were used in Experiments 3a and 3b. Experiment 3a included the OSIQ (Blajenkova et al. 2006). Participants responded on a 5-point scale (1 = *totally disagree*, 5 = *totally agree*); note that *higher* scores indicate superior visual imagery ability.

Design

Experiment 3a was based on a 4 (Trial Type: CC, WW, CW, WC) $\times$ 2 (Condition: standard, elaboration) mixed-factor design with Condition as the between-participants factor. Experiment 3b had a 4 (Trial Type: CC, WW, CW, WC) $\times$ 3 (Condition: standard, elaboration zoom in, elaboration zoom out) mixed-factor design with Condition as the between-participants factor.

Procedure

The procedure was identical to that of Experiment 1b (15 s of study exposure), but now run on the same apparatus as Experiment 1a and with “imagine left–right” and “zoom” instructions. In Experiment 3a, participants in the elaboration condition viewed the picture without instructions for 5 s. Text then appeared above the photograph to instruct participants to imagine what the photographer would see to the left of the scene (5 s). Finally, text appeared below the photograph to instruct participants to imagine what the photographer would see to the right of the scene (5 s). Following the BE trials, the final block of the experiment was the OSIQ, with participants indicating their agreement to each statement using the keypad.

In Experiment 3b, the participants in the elaboration conditions were shown two examples of what it would look like if a photographer zoomed in 80 % and 60 % (or out 120 % and 140 %; see Fig. 5 for the examples used in the instructions). Participants viewed each picture without instructions for 5 s. Text then appeared above the photograph to instruct participants to imagine what they would see if they zoomed in 80 % (or out 120 %) for 5 s. Finally, text appeared below the photograph to instruct participants to imagine what they would see if they zoomed in 60 % (or out 140 %). The OSIQ was not included in Experiment 3b, due to the experimental session duration.

Fig. 5 Examples presented to participants in Experiment 3b: Zooming in (A) and zooming out (B)

A. Zooming in, you would see less of the horizon...

Original view

80%

60%

Zooming in, you would see less of the building...

Original view

80%

60%

B. Zooming out, you would see more of the horizon...

Original view

120%

140%

Zooming out, you would see more of the building...

Original view

120%

140%

Results

Confidence ratings

Participants were confident in their ratings: for the left–right (Exp. 3a) elaboration instructions, they reported being *sure*, *pretty sure*, and *not sure* on 41 %, 41 %, and 14 % of trials, respectively; for the standard instructions, these responses were 39 %, 40 %, and 17 % of the total. Participants indicated that they did not remember the picture on 3 % of trials under elaboration instructions, and on 4 % under standard instructions. For the zoom conditions (Exp. 3b), with zoom-in elaboration instructions participants were also confident—33 %, 50 %, and 13 %; for zoom-out elaboration, these values were

31 %, 46 %, and 17 %; and for the standard condition, they were 30 %, 56 %, and 14 %. Participants chose *did not see picture* on 3 % of trials for zoom in, on 6 % for zoom out, and on 1 % for standard.

BE scores

The mean boundary ratings and 95 % confidence intervals are presented in Fig. 6. For both experiments, in the first of the three critical comparisons, significant negative ratings for both CC and WW trials indicated BE for both types of “same” trials. Second, participants gave larger ratings to WC than to CW trials. Third, we found no effect of instruction condition

Fig. 6 Mean boundary ratings for the standard and elaboration conditions in Experiments 3a (A) and 3b (B). (A) The experimental group was asked to imagine what was to the left and right of each scene at study. (B) The experimental groups were asked to imagine zooming in

(“left–right” or “zoom,” as compared with standard) in either experiment.

Experiment 3a (left–right) For the “same” trials, a 2 (Trial Type: CC, WW) $\times$ 2 (Instruction Set: standard, elaboration) mixed-design ANOVA revealed a main effect of trial type, $F(1, 68) = 5.95, p = .02, \eta^2 = .08$, indicating stronger BE for CC than for WW trials. There were no main effect of instructions, $F(1, 68) < 1$, and no interaction, $F(1, 68) < 1$. For “different” trials, a 2 (Trial Type: CW, WC) $\times$ 2 (Instruction Set: standard, elaboration) mixed-design ANOVA revealed a main effect of trial type, $F(1, 68) = 106.19, p < .001, \eta^2 = .61$, indicating that participants gave larger ratings to WC than to CW changes from study to test, replicating previous work (e.g., Dickinson & Intraub, 2008). No main effect of instructions emerged, $F(1, 68) < 1$, and no interaction, $F(1, 68) < 1$. Note that the absolute values of the CW and WC scores were used in the ANOVA, in order to compare participants’ use of the scale (Dickinson & Intraub, 2008).

Experiment 3b (zoom in/out) For the “same” trials, a 2 (Trial Type: CC, WW) $\times$ 3 (Instruction Set: standard, elaboration zoom in, elaboration zoom out) mixed-design ANOVA revealed a marginal main effect of trial type, $F(1, 46) = 3.67, p = .06, \eta^2 = .07$, indicating similar BE for CC and WW trials, with a trend toward more BE in CC than in WW. We observed no main effect of instructions, $F(2, 46) = 1.43, p = .25, \eta^2 = .06$, and no interaction, $F(2, 46) < 1$. For “different” trials, a 2 (Trial Type: CW, WC) $\times$ 3 (Instruction Set: standard, elaboration zoom in, elaboration zoom out) mixed-design ANOVA revealed a main effect of trial type, $F(1, 46) = 56.61, p < .001, \eta^2 = .55$, indicating that participants gave larger ratings to WC than to CW changes from study to test, replicating previous work (e.g., Dickinson & Intraub, 2008). There

or zooming out (between participants). Negative ratings indicate that the test scene appeared to be closer than the original, and ratings of 0 indicate that the test scene appeared identical to the original. Error bars indicate 95 % confidence intervals of the means. C = close-up, W = wide-angle

were no main effect of instructions, $F(2, 46) < 1$, and no interaction, $F(2, 46) < 1$.

Object and spatial imagery

We found individual differences in self-reported imagery ability in Experiment 3a, the study in which the OSIQ was included, with a significant difference between the top and bottom quartiles for the OSIQ object imagery and spatial imagery scores (see Table 1). In Experiment 3a (left–right), the top and bottom quartiles for object imagery were statistically different, $t(34) = 15.42, p < .001, d = 17.00$, and the same pattern held for spatial imagery, $t(34) = 14.65, p < .001, d = 12.63$. There was no difference between the CC scores for those in the top ($M = -0.42, SD = 0.38$) and bottom ($M = -0.38, SD = 0.35$) quartiles for object imagery, $t(34) = 0.34, p = .73, d = 0.11$. However, when CC scores were sorted by spatial-imagery scores, we did find a difference between the CC scores for those in the top ($M = -0.55, SD = 0.37$) and those in the bottom ($M = -0.28, SD = 0.26$) quartile, $t(34) = 2.52, p = .02, d = 0.84$. Participants who self-reported higher spatial imagery had larger (more negative) BE scores. In addition, a significant correlation emerged between spatial imagery and CC scores (higher imagery being associated with more-negative BE scores, $r = -.24, p < .05$), but not between object imagery and CC scores ($r = -.08, n.s.$).

Discussion

Robust BE was again observed for both CC and WW trials. Participants again gave larger ratings to WC than for CW trials, with participants responding “same” to CW trials on the rating scale. Once again, the instructions (standard or elaboration) did not affect BE scores.

Unlike in Experiments 2a and 2b, which were challenged by relatively small sample sizes, in Experiment 3a we observed a relationship between the spatial imagery subscale of the OSIQ and boundary extension, with self-reported strong-spatial-imagery participants showing relatively large BE (the OSIQ was not included in Exp. 3b). By contrast, neither the VVIQ (Exp. 1b) nor the object subscale of the OSIQ (Exp. 3a), both of which assess pictorial memory, were significantly related to BE scores. This contrasting pattern of spatial imagery being related to BE and pictorial imagery not being related to it makes intuitive sense, in that BE is spatial in nature. Future studies of BE should explore this further to clarify the role of individual differences in BE and why those may occur. Such an understanding would further inform the mechanisms that underlie BE itself.

General discussion

In the present series of six experiments, we examined whether various kinds of elaborative imagination enhance BE. Inspired by the proposal that BE results from a combination of scene representation being multisourced (Intraub, 2010; Intraub & Dickinson, 2008) and subsequent source memory errors (e.g., Johnson et al. 1993), we developed study conditions to parallel elaborations that have been known to increase source memory errors for actions (Thomas et al. 2003). We asked participants to imagine additional sensory information while they were trying to remember photographs. Regardless of whether we asked them to imagine additional sounds, odors, tastes, or even visually what more of the photograph would look like, elaboration did not increase BE. Elaboration also did not reduce BE, which might have occurred if the act of generating additional information improved accuracy, as Foley et al. (2010) had found within the Deese/Roediger–McDermott paradigm for word and picture lists.

We found significant BE effects in all six experiments. Two key markers of BE showed up in every experiment—namely, that (a) CC trials and WW trials yielded BE, and (b) WC trials showed more BE than CW trials. Surprisingly, neither of these patterns was affected by cross-modal elaboration (Exps. 1a, 1b, 2a, and 2b) or visual elaboration (Exps. 3a and 3b). Our results were consistent across both RSVP (Exps. 2a and 2b) and blocked (the four other experiments) BE methods. The same patterns were reported with relatively short study periods (6 s in Exp. 1a) and relatively long study periods (15 s in Exp. 1b), and with both within-participants (Exps. 2a and 2b) and between-participants (Exps. 1a, 1b, 3a, and 3b) manipulations of instruction conditions. In short, with a variety of procedures, all of which resulted in clear BE, we found no evidence that elaboration had any effect on BE. BE may well be a source memory error, but explicit imagination does not

appear to contribute to the misremembered boundaries of the originally presented visual stimulus.

Our experiments do tell us some interesting things about BE. In order to allow for substantial elaboration, we used photographs that were much more varied (in terms of the number of objects presented and wide-angle landscape views) than the typical BE photographs. With these photographs, participants had significant BE even for WW trials (which often show accurate performance; Exps. 1a, 1b, 3a, and 3b show this most clearly). Participants still gave larger ratings to WC than to CW trials, but with the world set of photographs, even CW trials were rated as being closer (Exps. 1a and 1b). Finding robust BE for a very different range of photographs highlights that BE is not limited to photographs with single, central objects. Experiments 2a and 2b actually allowed for a comparison of the world pictures used in most of our experiments with more typical BE pictures, with no difference emerging in how participants rated the pictures. Scenes can be quickly classified in a variety of ways, including by structural properties such as openness, constancy properties such as temperature, and functional properties such as navigability (e.g., Greene & Oliva, 2009a, b). Future research could examine whether these properties influence BE, though the present experiments suggest that structural and functional properties would be more likely to influence BE than constancy properties, given the correlation with spatial, but not object, imagery.

Within the multisource model of spatial representation, amodal completion is included as a contributor to BE (Intraub, 2010, 2012), and the strength of this contribution has been recently highlighted using very abstract scenes (Hale, Brown, McDunn, & Siddiqui, 2015; McDunn, Siddiqui, & Brown, 2014). In fact, an occluded edge is not enough to highlight the limited scope of a view (McDunn et al. 2014), and Hale et al. had to present extremal edges to stop participants from extending the boundaries of scenes of random abstract polygons on a field of random dots. Even with very abstract scenes—indeed, scenes with only surfaces and no objects—participants misremembered information from amodal completion as to what had been seen, showing source confusion, in support of BE as a source memory error (Hale et al. 2015; McDunn et al. 2014). The range of scenes across which BE is observed is quite broad, from the abstract shapes of Hale et al. and McDunn et al. to the rich world pictures of cities and markets in the present work.

We generally found more BE for the blocked procedure, and in particular the CW trials showed negative (“closer”) ratings (Exps. 1a, 1b, 3a, and 3b) so that often they were correctly identified as being wider at test (as in Exps. 2a and 2b). In the RSVP procedure, participants are asked to remember three or four specific photographs for a much shorter duration of time, which might contribute to this different pattern for CW trials than with the blocked procedure. Dickinson and

Intraub (2008) did vary the study time in an RSVP procedure, but with a much smaller range (42–1,000 ms), and found no effect of study time on BE. Regardless of the procedure, BE patterns were observed, and elaboration did not influence the BE ratings.

We also explored whether participants' self-reported visual imagery abilities correlated with their BE scores. Using the VVIQ, we found no relationship between pictorial imagery scores and BE (Exp. 1b). Using the OSIQ, we only found a significant correlation between BE scores and the spatial imagery subscore (Exp. 3a). However, we found no correlation with OSIQ and BE in Experiments 2a and 2b—which is perhaps not surprising, given the relatively low *n* in those within-participants experiments. It is important to note that participants *did* self-report a range of imagery ability and facility; these ratings just were not related to their BE scores. The only case in the present series of experiments in which a significant correlation occurred was when the elaboration condition was visuospatial (“imagine what would be to the left and right”). This is an intriguing new finding to explore within the BE literature.

Imagination, particularly rich sensory details, increases source memory errors for actions (Thomas et al. 2003). However, the act of imagining isolated objects improves memory, reducing source memory errors (Foley et al. 2010). Being specifically asked to elaborate either cross-modally (Exps. 1a, 1b, 2a, and 2b), or simply to imagine more visual input (Exps. 3a and 3b), led to no change in BE scores. Foley (2012) distinguished between spontaneous and intentional imagery; she argued that the latter allows participants to use records of cognitive operations to avoid false recognition (source memory) errors. In the present series of experiments, visual information was critical to deciding whether the angle of a test picture was the same, closer, or wider than its study-phase counterpart. By contrast, imagined sounds, smells, or tastes would be the same, regardless of visual angle. Experiments 1a, 1b, 2a, and 2b focused on cross-modal elaboration (“imagine odors and sounds, also tastes” in Exp. 2b), so any visual imaginings would have been spontaneous. In Experiments 3a and 3b, by contrast, elaboration condition participants were instructed to imagine what was left or right of the shown scenes (3a) or to imagine zoomed-in or zoomed-out versions of the photographs (3b), so visual imaginings were intentional. Importantly, neither type of imagining resulted in a reduction of BE as compared with the standard-instruction conditions. We see this as a strength of this series of experiments, since it added generalizability to the conditions tested and failed to show modulation of the size of BE.

We fully acknowledge that null results are difficult to interpret, yet we used a wide range of methods (e.g., within- and between-participants designs, blocked and RSVP presentation, cross-modal and visual elaboration, short and long study times, world and object pictures, and spontaneous and

intentional visual imagery) and failed to find an effect of elaboration instructions that have been effective in other source memory tasks (e.g., Foley, 2012; Foley et al. 2010; Thomas et al. 2003). At this point, we can only say that we do not have evidence to support the idea that explicitly imagined details can be misconstrued as visual information from a scene, and thus contribute to BE.

However, we also focused our investigation on the effect of elaborative imagery on BE. Future work should draw from other conditions that have been shown to increase or decrease source memory confusions (for a review, see Lindsay, 2008). For example, consider the Deese-Roediger-McDermott paradigm, in which participants misremember lures as being part of the original list. When participants are reminded of all possible sources with options on a memory test (e.g., *heard the word*, *did not hear the word*, *did not hear the word but self-generated it*, and *both heard and self-generated it*), source misattributions are reduced (Multhaup & Conner, 2002, Exp. 2b; see Multhaup, 1995, for a similar pattern with the false-fame task). Moreover, Multhaup and Conner's participants were more likely to identify critical nonpresented lures as *not heard but generated* than as *heard and generated*, whereas they were more likely to identify the critical presented words as *heard and generated* than as *not heard but generated*. This pattern is consistent with participants evaluating information regarding auditory and cognitive operations as they assign the sources of test items. Exploring BE with an analogous set of test options that reminded participants of multiple possible sources on each trial (e.g., *picture identical to one studied*, *picture closer than one studied*, *picture further away than one studied*, *picture identical to one studied but seems closer because I imagined what was beyond the original picture*, *picture identical to one studied by seems farther away because I did a mental close-up of the details of the original picture*) may yield less BE than standard instructions. Identifying which, if any, manipulations affect BE will further our understanding of the extent to which BE is a source memory error.

An additional clue about the driving force behind BE might be drawn from Intraub et al. (2008), who showed that divided attention increases BE. When participants were asked to perform a difficult visual search task superimposed over a photograph, increased BE for the photograph was observed (Intraub et al. 2008). The researchers argued that the divided attention made it more difficult for participants to identify at test what had been amodally completed. In a similar vein, we have preliminary data suggesting that hand position, which affects the focus of attention (Abrams, Davoli, Du, Knapp, & Paull, 2008; Davoli & Abrams, 2009; Davoli, Brockmole, Du, & Abrams, 2012; Davoli, Brockmole, & Goujon, 2012; Davoli, Du, Montana, Garverick, & Abrams, 2010), also affects the size of BE. Whereas divided attention increases BE because participants misattribute amodally completed details

to the original scene (Intraub et al. 2008), increased attention from hand placement seems to reduce BE.

Yet another approach to BE is to focus on the spatial nature of the task. There is some evidence that spatial awareness, as measured by BE, is quite separate from memory (Kim, Dede, Hopkins, & Squire, 2015). Patients with lesions limited to the hippocampus demonstrated as much BE as controls in both a drawing task and an RSVP task. Both groups were also sensitive to instructions regarding the likelihood of pictures in the RSVP task actually being the same. By contrast, patients' drawings were rated as being less accurate than controls' drawings were, and participants had lower recognition scores for the names of objects in the scenes than did controls. In a further experiment, patients with hippocampal damage included fewer sensory descriptions when asked to imagine what would be just out of view, but they provided spatial information similar to that of controls. Patients also had lower recall scores for the scenes they had been asked to extend. Kim et al. argued that the hippocampus is critical for memory, but damage to this region does not affect spatial awareness; thus, patients with hippocampus damage show impaired memory but preserved BE. The spatial nature of BE is also supported by Intraub et al. (1998) finding that BE is influenced in healthy young adults by instructions to imagine specific spatial backgrounds, and by the present report of a positive correlation between the spatial subscale of the OSIQ and BE (Exp. 3a).

In summary, with six experiments that covered a range of design manipulations, we found no evidence that elaborative imagination affects the size of BE. We did, however, find a hint that spatial imagery ability may lead to greater BE. Further exploration of such individual differences and the roles of source-memory, attentional, and spatial processes in BE will be instructive in explaining why BE occurs.

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