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Effects of pointing compared with naming and observing during encoding on item and source memory in young and older adults

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ABSTRACT

Research showed that source memory functioning declines with ageing. Evidence suggests that encoding visual stimuli with manual pointing in addition to visual observation can have a positive effect on spatial memory compared with visual observation only. The present study investigated whether pointing at picture locations during encoding would lead to better spatial source memory than naming (Experiment 1) and visual observation only (Experiment 2) in young and older adults. Experiment 3 investigated whether response modality during the test phase would influence spatial source memory performance. Experiments 1 and 2 supported the hypothesis that pointing during encoding led to better source memory for picture locations than naming or observation only. Young adults outperformed older adults on the source memory but not the item memory task in both Experiments 1 and 2. In Experiments 1 and 2, participants manually responded in the test phase. Experiment 3 showed that if participants had to verbally respond in the test phase, the positive effect of pointing compared with naming during encoding disappeared. The results suggest that pointing at picture locations during encoding can enhance spatial source memory in both young and older adults, but only if the response modality is congruent in the test phase.

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Item memory; source memory; pointing gestures; encoding strategy; ageing

Most people are familiar with the experience of knowing that they have seen an item, for example, their key chain, but do not remember *where* it was the last time they have seen it. This example illustrates the finding that humans have more trouble remembering the contextual information associated with content information, than with remembering content information in isolation, that is, they have more trouble with source memory, than item memory (Van Petten, Senkfor, & Newberg, 2000). The present study investigated whether source memory for picture locations can be improved by making pointing gestures towards the locations during encoding, in young and older adults.

Source memory and ageing

Research showed that source memory performance is often less accurate and more sensitive to ageing than item memory performance (e.g., Bastin & Van der Linden, 2005; Bayer et al., 2011; Spencer & Raz, 1995; Swick, Senkfor, & Van Petten, 2006; Trott, Friedman, Ritter, Fabiani, & Snodgrass, 1999). To explain this age-related decline in source memory, Naveh-Benjamin (2000) proposed the associative deficit hypothesis (ADH), which hypothesises that older adults have a binding problem for integrating different units of information, such as content and context information into an associated memory. This hypothesis has been supported in numerous studies (e.g., Bastin & Van der Linden, 2005; Naveh-Benjamin, Guez, Kilb, & Reedy, 2004; Naveh-Benjamin, Hussain, Guez, & Bar-On, 2003). Other evidence showed that increased demands on cognitive control functions, such as attentional processes, during the encoding phase but not the retrieval phase negatively affect source memory performance (Anderson, Craik, & Naveh-Benjamin, 1998). Anderson et al. (1998) compared source memory performance in a full attention condition (single task performance) with source memory performance in a divided attention condition (dual task performance), in which a secondary task was either performed during the encoding or retrieval phase. Results showed that memory performance suffered from divided attention during encoding, but was hardly affected by divided attention during retrieval. Furthermore, Anderson et al. (2000) showed that young adults' source memory performance in a divided attention condition was comparable with that of older adults in a full attention condition.

Interestingly, cueing attention during encoding seems to enhance source memory in young and older adults. For example, Glisky, Rubin, and Davidson (2001) showed

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that providing a verbal cue improved source memory in older adults up to the level of young adults. Participants were cued in the form of a question ("do you think this chair fits the room?") during the encoding of content–context associations (chair–room associations). Because source memory is error prone in general, and declines as a function of age, an important question is whether and how it can be improved, especially in older adults.

The studies described above suggest that successful source retrieval depends on the quality of encoding including attentional processes (that seem to decline with ageing) during encoding. The present study investigated another possible way to enhance source memory by improving the quality of encoding, namely with gesturing.

Improving source memory with action: effects of enactment and gesturing

Research on the enactment effect has convincingly shown that enacting action phrases compared with listening to them leads to superior source memory in young (e.g., Engelkamp, 1998; Nilsson, 2000; Zimmer, 2001) and older adults (Feyereisen, 2009). In explaining this effect, Kormi-Nouri and Nilsson (2001) stated that the enactment of an action phrase encodes and stores the elements (the object and the action) in the sentence as an integrated event in memory. Note, though, that asking people to literally enact activates people to act out or pantomime the sentence, whereas listening is rather passive. Feyereisen (2009) took this possible confound into account and added a third condition to the passive listening and enactment condition. In this third condition, participants observed the experimenter enacting the action phrases with pantomimes. Results showed that passive observation of the experimenter's gestures also led to superior source memory compared with passive listening, and there was no difference between the self-performed and experimenter performed enactment. Importantly, Feyereisen showed that both young and older adults benefited from enacting or observing the actions.

In their review on the effect of action on memory, Madan and Singhal (2012) suggest that other kinds of gestures (being motor actions) can enhance memory in a similar manner as enactment does. Indeed, evidence showed that producing gestures can also facilitate memory (e.g., Cook, Yip, & Goldin-Meadow, 2010) and learning (for a review, see Goldin-Meadow & Alibali, 2013). For example, Cook et al. (2010) found that gesturing during the encoding of action/motion events improved immediate and delayed free recall. In addition, both observing and making gestures seem to activate the motor system (Schippers, Gazzola, Goebel, & Keysers, 2009), which suggests that gesturing can add a motoric component to the memory. In relation to the age-related binding problems, proposed by the ADH (Naveh-Benjamin, 2000), the integrative function of gestures might be especially helpful in improving source memory in older adults.

Note that these studies concern mainly enactment and symbolic gestures, not deictic gestures (i.e., pointing and tracing used to index locations and movement pathways in space). Moreover, even though gestures are often made in interaction, not all gestures have communicative purposes. Yet even non-communicative and deictic gestures may benefit memory processes. For example, Chu and Kita (2011) showed that during the performance of a mental rotation task, participants who were encouraged to gesture (co-thought gestures) solved more problems than those who were not encouraged but allowed to gesture or those who were prohibited from gesturing. Chu and Kita proposed that these so-called co-thought gestures offload the internal computation (i.e., working memory) processes needed to make the spatial transformations, thereby improving performance. There is some evidence that non-communicative deictic gestures during the encoding of object–location associations can also support working memory processes. For instance, Chum, Bekkering, Dodd, and Pratt (2007) found that pointing at simple figures (e.g., circles) at different locations enhanced visuospatial working memory. In addition, several studies show that deictic gestures of a speaker are used to help focus attention to an object in space or a location in a social situation (Bangerter, 2004; Louwerse & Bangerter, 2005; Peeters, Azar, & Özyürek, 2014).

In summary, adding a motoric code during memory encoding by enactment can enhance source memory (Engelkamp, 1998) in young and older adults (Feyereisen, 2009). Furthermore, adding a motoric code by pointing during encoding can enhance spatial working memory (Chum et al., 2007) and help focus attention (Bangerter, 2004; Louwerse & Bangerter, 2005; Peeters et al., 2014). However, it is important to mention that Feyereisen (2009) compared the enactment condition with a passive verbal (listening) condition, not an active verbal condition. It is possible that the beneficial effects of enactment found by Feyereisen were due to activity as such, rather than specific actions. Moreover, the effect of gestures might depend on the nature of the gestures and the task at hand and the question of whether source memory improves from deictic gestures has not yet been addressed (although there is evidence that deictic gestures may support working memory processes: Chum et al., 2007). Because cognitive and attentional control processes (e.g., Braver & Barch, 2002) decline with ageing, which is especially problematic for the encoding phase in source memory tasks (e.g., Anderson et al., 1998, 2000), gesturing during encoding might be a promising tool to enhance source memory, especially for older adults. Therefore, the present study will compare the effects of gesturing (pointing) with an active verbal processing strategy (naming) on young and older adults' item and source memory in Experiment 1.

The present study

To the best of our knowledge, the effect of self-produced deictic gestures (pointing) on spatial source memory in young and older adults has not been investigated yet. Therefore, in the present study, three experiments investigated whether pointing at picture locations would lead to better source memory for these locations than verbally naming (Experiment 1) or only visually observing (Experiment 2) the pictures, in young and older adults. Encoding strategies (pointing versus naming and pointing versus observation only) were tested within participants. In Experiments 1 and 2, the responses in the test phase of each condition had to be made manually on a touch screen. To investigate whether the response modality in the test phase (motor or verbal) would influence item and source memory test performance, Experiment 3 replicated Experiment 1, but asking participants for a verbal response in the test phase.

It was hypothesised that pointing at the picture locations during encoding would lead to better source memory in both young and older adults compared with naming (Experiment 1) and visual observation only (Experiment 2) of the picture locations. Furthermore, it was hypothesised that because of age-related declines in source memory, positive effects of pointing gestures would be larger in older than in young adults. Overall, it was expected that older adults would perform equally well on item memory as young adults, but would perform more poorly on source memory. Finally, because source memory seems to rely on the quality of encoding (e.g., Anderson et al., 1998; Glisky et al., 2001), it was expected that congruency of response modality between the encoding and test phases would not influence subsequent item and source memory performance. Or, in other words, it was expected that any effects of encoding strategy (i.e., pointing versus naming) in Experiment 1 in which the test phase required manual responses would be replicated in Experiment 3, in which in the test phase required verbal responses.

General method

Materials

All materials were computerised, programmed in E-prime 2.0, and presented on a 17-inch ELO touchscreen with a 1024 × 768 resolution, tilted backwards at a visual angle of 30°.

Operation span task. The operation span task (Unsworth, Heitz, Schrock, & Engle, 2005) was administered to obtain a general measure of cognitive functioning. These types of working memory span tasks have been found to predict performance on a wide range of cognitive tasks (Engle, Tuholski, Laughlin, & Conway, 1999; Kane, Bleckley, Conway, & Engle, 2001) and share a large amount of variance among each other, indicating they measure the same construct (Unsworth et al., 2005). Although a large body of evidence indicates that older adults show age-related declines in cognitive functioning compared with young adults, such as working memory (e.g., Cabeza & Dennis, 2013; Conway et al., 2005), this measure was taken to check whether this was also the case in the present sample and to find out whether operation span performance is a useful covariate for the analyses on item and source memory.

Source memory task. Picture stimuli were 156 coloured drawings from a subset of the materials of Rossion and Pourtois (2004).

Procedure

Operation span task. Participants were presented with arrays of letters intermixed with arithmetic problems they had to solve. Each trial started with a letter, followed by a problem, followed by a letter, etc. In total, 75 letters and 75 problems were presented in trials randomly varying in length from 3 to 7 letter-problem pairs. The task started with a 5 min training in which participants first practiced the letter- and the problem-solving tasks separately and in the final training phase, together. Then, the operation span task automatically followed, which took about 10–15 min to complete. One point was assigned for each letter that was recalled in the correct position in the array, which could result in a maximum score of 75.

Source memory task. The general procedure of the source memory task was roughly the same in all experiments. Participants were tested in individual sessions of approximately 20 min. In total, 156 pictures were used, including the 12 pictures used for the training phase. A sample of 144 pictures was used for the actual experiment consisting of 72 pictures of natural objects (such as animals and plants) and 72 pictures of artificial objects (such as furniture and clothing). However, encoding strategies were manipulated within participants and differed between experiments, as specified below.

Encoding phase. The source memory task started with a short training phase in which participants were familiarised with the procedure of the trials in the encoding and test phases. Of the 144 pictures used, 12 (6 natural and 6 artificial) were used in the training phase. Then, the experiment started with the encoding phase. Of the 144 pictures used, 96 (48 natural and 48 artificial) were used in the encoding phase. Each of the 96 encoding trials started with the presentation of an empty quadrant dividing the screen in 4 areas. Participants were instructed to fixate on a cross that was located at the centre of the screen. After 1000 ms, a picture was presented off-centre towards the middle of the screen at one of the four locations until a response was detected or until the maximum presentation time of 2000 ms had passed (Figure 1). In the pilot study, Experiment 1, and Experiment 3, participants were instructed to categorise the pictures as "natural" or "artificial" by pointing with their index finger at the pictures of

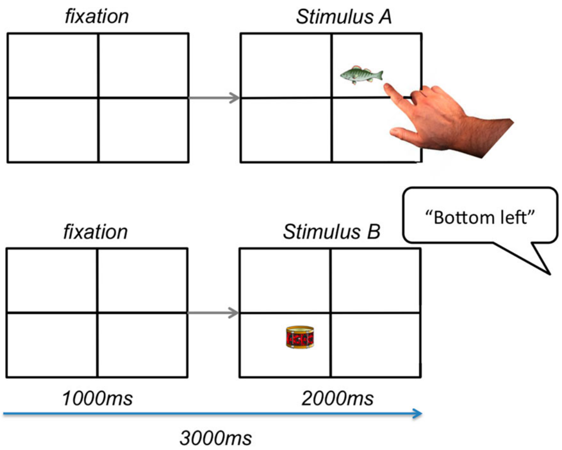

Figure 1. Example of both types of stimulus–response pairs in the encoding phase. In this example, locations of natural pictures (stimulus A) had to be pointed at and that of artificial pictures (stimulus B) named. Stimulus–response couplings were counterbalanced between participants.

one category and naming the location of the pictures of the other category. Naming was done by verbalising one of the following phrases "top left", "top right", "bottom left", or "bottom right", choosing the phrase that corresponded to the location of each picture. Half of the participants were instructed to point at the "natural" pictures and name the "artificial" picture locations and the other half were instructed to point at the "artificial" pictures and name the "natural" picture locations. In Experiment 2, participants had to categorise the pictures by pointing at or only visually observe the pictures, and again, stimulus–response couplings were counterbalanced between participants.

Reaction times of the pointing responses were recorded by the touchscreen as soon as the participants touched the screen. The verbal responses were made in a microphone positioned next to the participants' heads and reaction times were recorded as soon as the participants started their verbal response. Accuracy of the pointing response was automatically registered in the E-prime software. Accuracy of the verbal response was logged by the experimenter pressing a "1" for a correct response and a "0" for an incorrect response. To control for effects of picture sampling, 3 different sets of 96 pictures were randomly selected for the encoding phase. This resulted in three versions of the same task and the presentation of each version was counterbalanced between participants.

Test phase. In the test phase, 144 pictures were shown at the centre of the screen. Each trial started with a fixation cross at the centre of the screen, which was replaced after 1000 ms by a picture, which was visible for 1000 ms. In the pilot study, Experiment 1, and Experiment 2, participants had to make an old/new judgement deciding whether or not they had seen the picture in the encoding phase by pressing on the word "old" or "new" on the touchscreen as fast and accurately as possible. When participants judged the picture to be "new", they progressed to a new trial, but when they judged it to be "old", they were asked to judge at which of the four locations they had seen the picture during the encoding phase. Participants were instructed to make their source judgements as fast and accurate as possible by pressing one of the following words on the touchscreen, "top left", "top right", "bottom left", or "bottom right", corresponding to the words verbalised in the encoding phase in the naming condition (Figure 2). In Experiment 3, participants made the item and source memory judgements verbally in the microphone. Accuracy of the verbal response was logged by the experimenter pressing a "1" for "old" and "0" for "new" for the item memory responses and "1" for "top left" "2" for "top right", "4" for "bottom left", and "5" for "bottom right" for the source memory responses.

Data analysis

For both encoding conditions (i.e., pointing and naming in the pilot study, Experiments 1 and 3; pointing and observation only in Experiment 2), percentage scores were calculated for item memory, by dividing the total number of correct responses in each condition, by the maximum possible score divided by 100 (i.e., total correct item/(48/100)). This was also done for source memory by dividing the total amount of correct location judgements by the total amount of correctly recognised items divided by 100 (i.e., total correct source/(total correct item/100)). For the operation span task, a performance score was obtained by adding up all the correctly remembered letters in the arrays, which could lead to scores ranging between 0 and 75.

Pilot

Participants and design

Before experimental testing, the paradigm described above was pilot tested in 24 healthy young students (16 women, 8 men, $M_{age} = 22.1$ years, SD = 3.8 years, age range 18–32) enrolled at a Dutch University. They participated for course credits or voluntarily. A within-subjects design, with encoding condition (pointing versus naming) as within-subjects factor was used.

Results

Response accuracy for the pointed and named picture locations during the encoding phase was high (pointing, $M = 98.4\%$, SD = 2.4; naming, $M = 99.6\%$, SD = 1.4). The number of false responses during encoding was low (false pointing in the naming encoding condition, $M = 1.2\%$, SD = 2.8; false naming in the pointing encoding condition, $M = 0.4\%$, SD = 1.0).[1]

A repeated measures analysis of variance (ANOVA), with encoding condition as within-subjects factor, showed no effect of encoding condition on item memory accuracy

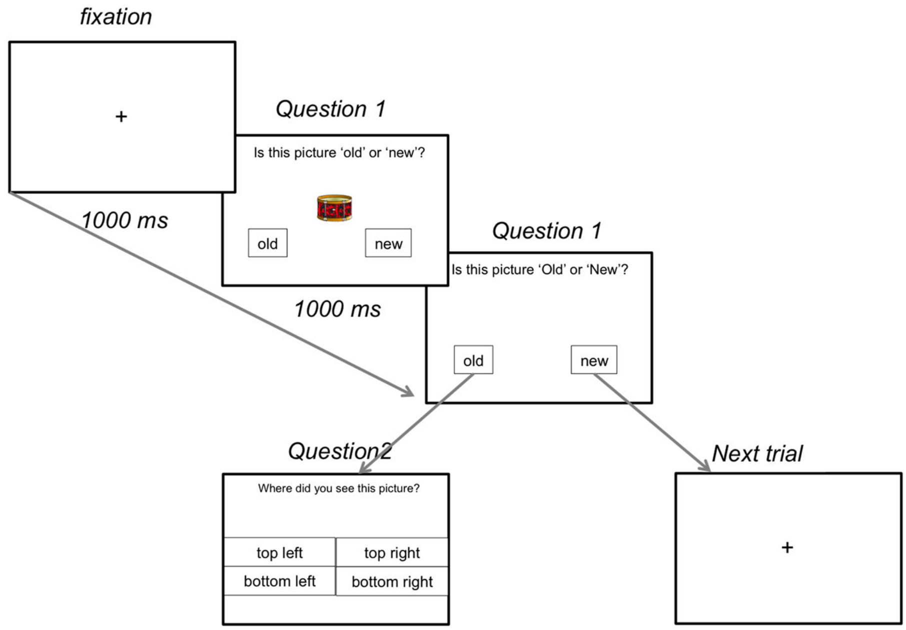

Figure 2. Example of a trial in the test phase.

(pointing, $M = 67.0\%$, SD = 15.9; naming, $M = 64.1\%$, SD = 11.7), $F(1, 23) = 0.68$, MSE = 153.22, $p = .417$, $\eta_p^2 = .03$. However, encoding condition did have a significant effect on source memory accuracy (pointing, $M = 61.8\%$, SD = 16.7; naming, $M = 53.9\%$, SD = 14.6), $F(1, 23) = 13.52$, MSE = 56.24, $p = .001$, $\eta_p^2 = .37$. These results supported the hypothesis that a motoric–visual encoding strategy of picture locations leads to higher source memory accuracy than a verbal–visual encoding strategy in young adults.

Experiment 1

Participants and design

Participants were 40 young adults and 40 older adults. One young participant was excluded because she was only 16 years old, leaving a sample of 39 participants for analysis (28 women, 11 men, $M_{age} = 20.8$ years, SD = 2.1, age range 18–26), who were all students enrolled at a Dutch university, and participated for course credits. The older adults (24 women, 16 men; $M_{age} = 67.0$ years, SD = 4.2, age range 60–83) were recruited via advertisements in local newspapers and community centres. Advertisements called for healthy older adults (>60 years of age) and during admission, participants were asked whether they had experienced a stroke (CVA (cerebrovascular accident) or TIA (transient ischemic attack)), dementia, other cognitive problems, or any kind of brain damage or (mild) head trauma in the past. Participants who answered yes to one of these questions were not included in the sample. The older participants received a small monetary reward for their participation. A mixed design with encoding condition (pointing versus naming) as within-subjects factor and age group (young versus older adults) as between-subjects factor was used.

Results

Operation span task. An ANOVA showed a significant difference in operation span score between young and older adults, $F(1, 77) = 27.90$, MSE = 260.50, $p < .001$, $\eta_p^2 = .27$, with, as expected, operation span in young adults being higher ($M = 41.11$, SD = 18.54) than in older adults ($M = 22.23$, SD = 13.39). Correlations between operation span scores and the four dependent variables (item and source memory performance for pointed and named picture locations) were calculated for each age group. No significant correlations were found (Table 1) and therefore, the operation span scores were excluded from further analysis.

Encoding. Response accuracy for the pointed and named items during the encoding phase was high for both the young adults (pointing, $M = 97.2\%$, SD = 5.3; naming, $M = 92.2\%$, SD = 10.0)[2] and the older adults (pointing, $M = 93.4\%$, SD = 7.5; naming, $M = 92.1\%$, SD = 9.0) The number of false responses during encoding was low for both the young adults (false pointing in the naming encoding condition, $M = 0.7\%$, SD = 1.1; false naming in the pointing encoding condition, $M = 0.7\%$, SD = 1.7) and the older adults (false pointing in the naming encoding condition, $M = 0.9\%$, SD = 1.10; false naming in the pointing encoding condition, $M = 0.7\%$, SD = 0.8).

Retrieval. Item and source memory performance and reaction times were analysed with 2 (encoding condition: pointing versus naming) × 2 (age group: young versus older adults) mixed ANOVAs with encoding condition as the repeated measure.

The analysis of item memory performance yielded a main effect of encoding condition, $F(1, 77) = 6.04$, MSE = 139.89, $p = .016$, $\eta_p^2 = .07$. These results show that item memory performance was higher in the pointing condition

Table 1. Correlation matrix of young and older adults' operation span scores with their item and source memory performance in Experiment 1.

	Pointing (n = 39)				*Naming (n = 40)*			
	Item		*Source*		*Item*		*Source*	
Age group	*R*	*p*	*R*	*p*	*R*	*p*	*R*	*p*
OSpan young adults	−.09	.596	−.02	.897	.05	.763	.24	.139
OSpan older adults	.22	.182	−.18	.278	.12	.480	−.09	.567

than in the naming condition (Figure 3). There was no effect of age group, $F(1, 77) = 1.42$, MSE = 363.91, $p = .237$, $\eta_p^2 = .02$, and no interaction, $F(1, 77) = 0.24$, $p = .623$, $\eta_p^2 < .01$. The ANOVA results regarding the reaction times of the item memory judgements revealed no effect of encoding condition, $F(1, 77) = 2.92$, MSE = 11,431.56, $p = .092$, $\eta_p^2 = .04$, age group, $F(1, 77) = 0.03$, MSE = 128,306.18, $p = .860$, $\eta_p^2 < .01$, and no interaction, $F(1, 77) = 0.79$, $p = .378$, $\eta_p^2 = .01$ (Table 2).

The analysis of source memory performance yielded a main effect of encoding condition, $F(1, 77) = 12.26$, MSE = 64.41, $p = .001$, $\eta_p^2 = .14$, and age group, $F(1, 77) = 12.04$, MSE = 445.57, $p = .001$, $\eta_p^2 = .14$, but no interaction, $F(1, 77) = 0.77$, $p = .383$, $\eta_p^2 = .01$. These results show that source memory performance was higher in the pointing condition than in the naming condition (Figure 3). Furthermore, they show that the older adults were outperformed by the young adults in both the pointing and naming conditions (Figure 3). The analysis of the reaction times of the source memory judgements revealed no effect of encoding condition, $F(1, 77) = 0.87$, MSE = 34,553.36, $p = .355$, $\eta_p^2 = .01$, age group, $F(1, 77) = 0.02$, MSE = 127,406.27, $p = .877$, $\eta_p^2 < .01$, or interaction $F(1, 77) = 0.96$, $p = .329$, $\eta_p^2 = .01$ (Table 2).

Discussion

The present data supported the hypothesis that pointing towards picture locations during encoding leads to better source memory for picture-location associations than verbally naming the locations. And this effect was found for both young and older adults. Overall, older adults had lower source memory performance than young adults. Interestingly, item memory in the pointing condition was also superior to item memory in the naming condition. A possible explanation is that naming compared with pointing at the picture locations was more unnatural. Finding the right words describing the location might have distracted attention away from the encoding of the content of the picture, which resulted in fewer pictures recognised in the item memory test. We return to this finding in the discussion of Experiment 2. No differences between young and older adults were found for item memory performance. This is in line with research showing that with ageing, source memory declines are more pronounced than item memory declines (for a meta-analysis, see Old & Naveh-Benjamin, 2008).

The second hypothesis that the effect of pointing on source memory would be larger in older adults than in young adults was not supported; no interaction between encoding condition and age group was found. Although source memory performance was higher for pointed picture locations than for named picture locations *within* age groups, young adults had better overall source memory performance than older adults, and older adults did not show a significantly larger difference between the pointing condition and the naming condition than young adults.

In summary, the present experiment showed an advantage in item and source memory performance for pictures of which the locations were pointed at, compared with named. Although the present study showed that pointing compared with naming during encoding leads to better memory performance, this might not necessarily prove that pointing enhances source memory for locations in general, because in both the naming and pointing

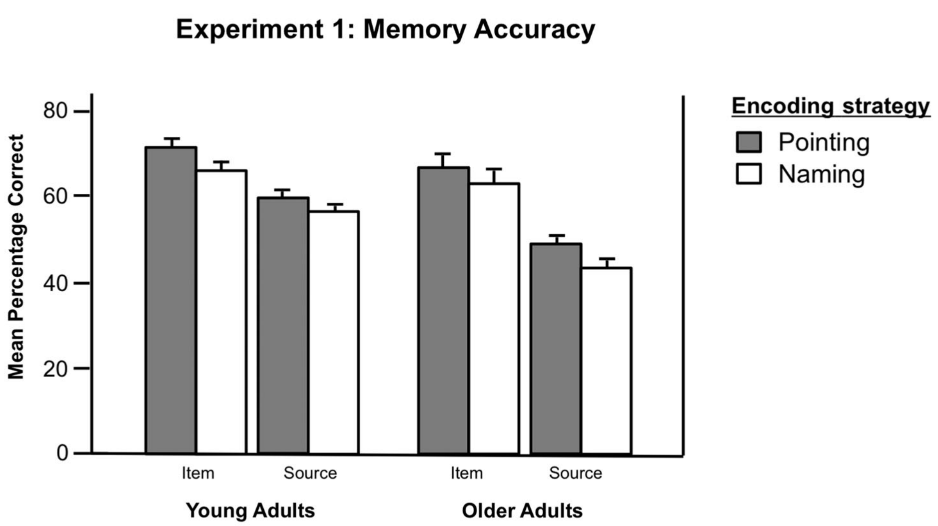

Figure 3. Item and source memory performance in Experiment 1 of the young and older adults for motorically (Pointing) and verbally (Naming) encoded picture locations expressed in percentage scores. Error bars represent standard errors: + 2 SE.

Table 2. Means and standard deviations of reaction times (ms) on the item and source memory test.

			Young adults				Older adults			
			Item		Source		Item		Source	
			M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Exp. 1	*n* (young) = 39	P	937	296	699	284	932	215	737	321
	n (old) = 40	N	951	282	700	275	976	259	680	253
Exp. 2	*n* (young) = 32	P	943	469	578	170	1109	434	1097	423
	n (old) = 28	O	1326	752	612	269	1526	738	1085	397
Exp. 3	*n* = 23	P	1270	1006	1139	447				
		N	1253	928	1196	514				

P, pointing; N, naming; O, observation only.

conditions, participants were required to actively respond to the location of the picture. Therefore, both the naming and pointing responses might have had some negative effects on encoding, but the current experiment did not allow for this assumption to be tested.

However, pointing might have been more a "natural" response to index a location than naming. To find out whether or not pointing leads to higher source memory performance than a more neutral condition in which no active response was required, the pointing condition was compared with a condition in which the participants passively observed the pictures in Experiment 2. The results of such an experiment would allow for determining whether pointing really has a positive effect on source memory or that it just has a smaller negative effect than naming. Although this alternative explanation seems unlikely based on the results of previous research showing positive effects of gestures on learning (for a review, see Goldin-Meadow & Alibali, 2013) and memory (Cook et al., 2010), it is necessary to exclude it before pointing can be identified conclusively as a strategy to improve spatial source memory.

Experiment 2

Experiment 2 used the same materials and procedure as Experiment 1, except for two changes. First, the operation span task was excluded as a premeasure because it did not correlate with the experimental task. Second, the naming condition was replaced with a condition in which participants passively observed the pictures (observation only condition).

Participants and design

Participants were 32 young adults (21 women, 11 men, $M_{age} = 19.8$ years, SD = 1.5, age range 17–23) and 28 older adults (17 women, 11 men, $M_{age} = 65.7$ years, SD = 3.7 age range 60–71). The recruitment procedure and reward of the participants were identical to those of Experiment 1. A mixed design with encoding condition (pointing versus observation only) as within-subjects factor and age group (young versus older adults) as between-subjects factor was used.

Results

Encoding. For experimental purposes, the same procedure was used as in Experiment 1 with the only exception that the verbal condition was replaced by an observation only condition. Response accuracy for pointing during the encoding phase was high for both the young (pointing: $M = 99.41\%$, SD = .01) and the older adults (pointing: $M = 98.81\%$, SD = .02). The number of false responses during encoding was low (pointing at pictures that should only be observed) for both the young adults ($M = 0.33\%$, SD = 1.51) and the older adults ($M = 0.52\%$, SD = 0.92).

Retrieval. Item and source memory performance and reaction times were analysed with 2 (encoding condition: pointing versus observation only) × 2 (age group: young versus older adults) mixed ANOVAs with encoding condition as the repeated measure.

The analysis of item memory accuracy showed no effect of encoding condition, $F(1, 58) = 0.12$, $MSE < 0.01$, $p = .735$, $\eta_p^2 < .01$, age group $F(1, 58) = 0.11$, MSE = 0.02, $p = .741$, $\eta_p^2 < .01$, or interaction, $F(1, 58) = 1.45$, $p = .234$, $\eta_p^2 = .02$ (Figure 4). Results regarding the reaction times of the item memory judgements revealed a main effect of encoding condition, $F(1, 58) = 48.86$, MSE = 108,973.94, $p < .001$, $\eta_p^2 = .43$, but no effect of age group, $F(1, 58) = 1.54$, MSE = 651,722.73, $p = .220$, $\eta_p^2 = .03$, or interaction, $F(1, 58) = 0.07$, $p = .787$, $\eta_p^2 < .01$ (Table 2). The main effect of encoding condition reflects the finding that both age groups were faster to make item recognition judgements for the pointed pictures than the observed pictures.

The analysis of source memory accuracy yielded a main effect of encoding condition, $F(1, 58) = 11.50$, MSE < 0.01, $p = .001$, $\eta_p^2 = .17$, and age group, $F(1, 58) = 10.24$, MSE = 0.04, $p = .002$, $\eta_p^2 = .15$, but there was no interaction, $F(1, 58) = 0.69$, $p = .409$, $\eta_p^2 = .01$ (Figure 4). These results show that source memory performance was higher in the pointing condition than in the naming condition. Furthermore, it shows that source memory of young adults was better than that of older adults in both the pointing and naming conditions. The ANOVA results of the reaction times of the source memory judgements revealed no effect of encoding condition, $F(1, 58) = 0.12$, MSE = 29,585.17, $p = .730$, $\eta_p^2 < .01$, a main effect of age group, $F(1, 58) = 40.58$, MSE = 181,072.04, $p < .001$, $\eta_p^2 = .41$, but no interaction, $F(1, 58) = 0.52$, $p = .473$, $\eta_p^2 < .01$ (Table 2). The main effect of age group reflects the finding that the

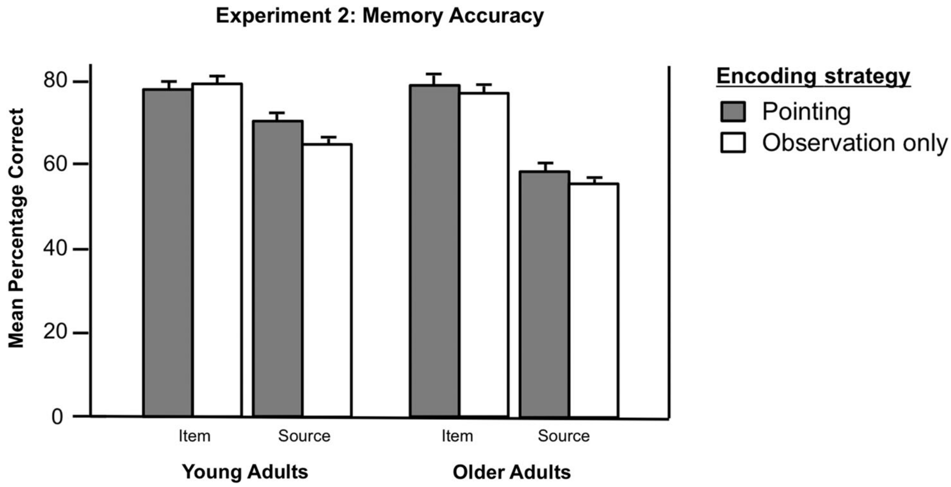

Figure 4. Item and source memory performance In Experiment 2 of the young and older adults motorically (Pointing) and visually (Observation only) encoded picture locations expressed in percentage scores. Error bars represent standard errors: + 2 SE.

older adults were slower to make source judgements than the young adults.

Comparison of performance between Experiment 1 and Experiment 2. From visual inspection of the means of the performance in Experiments 1 and 2 (Figures 3 and 4), it seems that participants performed better in Experiment 2 than in Experiment 1. To check this, two mixed ANOVAs were conducted, one for item memory accuracy and one for source memory accuracy, with between-subject factors for experiment (Experimen1 versus Experiment 2) and age group (young versus older adults). Analysis on item memory accuracy yielded an effect of experiment, $F(1, 135) = 26.69$, MSE $= 300.94$, $p < .001$, $\eta_p^2 = .17$, no effect of age group, $F(1, 135) = 1.15$, MSE $= 300.94$, $p = .285$, $\eta_p^2 = .03$, and no interaction, $F(1, 135) = 0.52$, $p = .518$, $\eta_p^2 < .01$. The analysis of source memory accuracy yielded an effect of experiment, $F(1, 135) = 15.20$, MSE $= 411.16$, $p < .001$, $\eta_p^2 = .10$, age group, $F(1, 135) = 21.59$, MSE $=$ 411,16, $p < .001$, $\eta_p^2 = .14$, but no interaction, $F(1, 135) = 0.09$, $p = .925$, $\eta_p^2 < .01$.

Discussion

In addition to Experiment 1 showing that pointing at picture locations is a better encoding strategy than naming them, Experiment 2 showed that pointing also led to better source memory in young and older adults compared with observation only. A surprising finding in Experiment 1 was that item memory performance was better in the pointing condition than in the naming condition. A possible explanation was that finding the right words to describe the location might have distracted attention away from the encoding of the content of the picture, resulting in fewer pictures being recognised in the item memory test. However, the observation only condition in Experiment 2 had no such drawbacks, but the pointing condition still had a beneficial effect on source memory. Therefore, the findings from Experiment 2 showed that this potential drawback of the naming condition in Experiment 1 could not explain why pointing led to better source memory performance.

The finding that participants in Experiment 2 outperformed those in Experiment 1 was unexpected considering the fact that the only difference between the two Experiments was that the naming condition of Experiment 1 was replaced by an observation only condition in Experiment 2. A possible explanation for this result is that the encoding phase in Experiment 1 was more difficult than in Experiment 2 and that this led to a general decline in subsequent memory performance. Note that the encoding conditions in Experiment 1 required task switching between two active responses (pointing and naming). To successfully encode the picture locations, the correct response had to be selected and executed, while at the same time, the other response had to be inhibited. In the encoding phase of Experiment 2, there was only one type of action (pointing) that had to be executed or inhibited, and therefore this encoding phase was presumably less effortful than that of Experiment 1.

Nevertheless, the results from the pilot, Experiment 1, and Experiment 2, suggest that pointing at picture locations during encoding has a positive effect on source memory for these picture-location associations. However, given that the response on the test also had to be given by pointing, it is possible that the positive effect of the pointing encoding strategy was not necessarily caused by properties inherent to pointing (adding a motoric component to the memory), but rather, by the compatibility between the response modality of the encoding and test phases (i.e., transfer appropriate processing, Morris, Bransford, & Franks, 1977; or encoding specificity, Tulving & Thomson, 1973). In other words, it cannot be ruled out that, had participants been required to verbally respond on the test, the pilot and Experiment 1 might have shown a benefit of naming over pointing. To address this alternative explanation, a third experiment was conducted.

Experiment 3

Experiment 3 replicated the pilot and Experiment 1 in terms of encoding, having participants engage in pointing versus naming picture locations, but now participants were required to verbally respond in the test phase. If source memory for the picture locations pointed at during encoding would still be superior to source memory for the picture locations verbally named, this would support the claim that pointing itself enhances source memory. However, if source memory for the named picture locations is superior to the ones pointed at, this would support the claim that the found effects in Experiments 1 and 2 would be an effect of response modality congruency between the encoding and test phases. On the basis of studies showing that successful source memory performance relies on the quality of encoding and not retrieval (e.g., Anderson et al., 1998; Glisky et al., 2001), it was expected that source memory performance for the pointed picture locations would be better than that for the named picture locations.

Participants and design

Participants were 23 young adults (15 women, 8 men, M_{age} = 21.1 years, SD = 1.5, age range 19–25). The recruitment and reward procedures of the participants were identical to those of the pilot. A within-subjects design with encoding condition (pointing versus naming) was used.

Results

Encoding. Response accuracy during the encoding phase was high for both the pointing (M = 96.8%, SD = .1) and the naming condition (M = 96.0%, SD = .04). The number of false responses during encoding was low (false pointing in the naming encoding condition, M = 0.6%, SD = 1.2; false naming in the pointing encoding condition, M = 1.5%, SD = 3.6).

Retrieval. The analysis of the item memory performance showed no effect of encoding condition on accuracy, $F(1, 22) = 0.18$, MSE = 0.01, $p = .672$, $\eta_p^2 < .01$, or reaction times $F(1, 22) = 0.17$, MSE = 17,399.50, $p = .682$, $\eta_p^2 < .01$. The analysis of source memory performance also did not show an effect of encoding condition on accuracy, $F(1, 22) = 0.01$, MSE < 0.01, $p = .939$, $\eta_p^2 < .01$, or reaction times, $F(1, 22) = 0.79$, MSE = 46,272.20, $p = .384$, $\eta_p^2 = .04$.

Comparison of performance between pilot/Experiment 1 and Experiment 3. The comparison of performance between Experiments 1 and 2 suggested that verbal responses during encoding negatively influenced performance compared with observation only. Because participants in Experiment 3 also had to provide verbal responses in the test phase, we wanted to rule out the possibility that this reduced their test performance in general. To check this, the data of Experiment 3 were compared with those of the pilot study, which used a similar sample (24 young adults) and paradigm (only the response modality in the test phase differed). A mixed ANOVA with encoding condition (pointing versus naming) as within-subject factor and test response modality (motoric versus verbal) as between-subject factor was conducted for source memory accuracy. Results showed a main effect of encoding condition, $F(1, 45) = 4.81$, MSE < 0.01, $p = .034$, $\eta_p^2 = .10$, no main effect of test response modality, $F(1, 45) = 0.50$, MSE = 0.05, $p = .484$, $\eta_p^2 = .01$, but a significant interaction between encoding condition and test response modality $F(1, 45) = 5.37$, MSE < 0.01, $p = .025$, $\eta_p^2 = .11$. Looking at Figure 5, it seems that performance in the pilot study and Experiment 3 was similar, except that for the pointing condition in the pilot study, in which accuracy seems higher. The results of the pilot study already showed that source memory performance in the pointing encoding condition was higher than in the naming encoding condition. In addition, two independent samples *t*-tests were conducted to test for (1) a difference between source memory accuracy in the pointing encoding condition of the pilot study and Experiment 3, and (2) a difference between the pointing encoding condition in the pilot study and the naming encoding condition in Experiment 3. Results showed no difference in source memory performance between the pointing encoding conditions of the pilot study and Experiment 3, $t(45) = 1.44$, $p = .158$, or between that of the pointing encoding condition in the pilot and the naming encoding condition in Experiment 3, $t(45) = -.183$, $p = .855$. These results indicate that performance accuracy between the pilot and Experiment 3 was similar. The interaction between encoding condition and test response modality reflects the finding that in the pilot study, an effect of encoding condition was found (see the main effect of encoding condition in the result section of the pilot study) but not in Experiment 3.

We did not assess reaction times in the pilot, so these can only be compared with Experiment 1. Visual inspection of the reaction times (Table 2) on the source memory test suggest that the responses in Experiment 3 (pointing, M = 1139 ms, SD = 447; naming, M = 1195 ms, SD = 514) were much slower than those in Experiment 1 (pointing, M = 699 ms, SD = 284; naming, M = 700 ms, SD = 275) who responded on the touch screen.

Discussion

The hypothesis that the pointing encoding strategy would lead to better source memory for picture locations than the naming encoding strategy, even when participants had to verbally respond in the test phase, was not supported. Instead, no effect of encoding strategy was found at all when participants verbally responded in the test phase. Note, however, that this null effect does not support the alternative possibility either. If it was the compatibility of the response modality between the encoding and test phases that led to superior source memory in the pilot

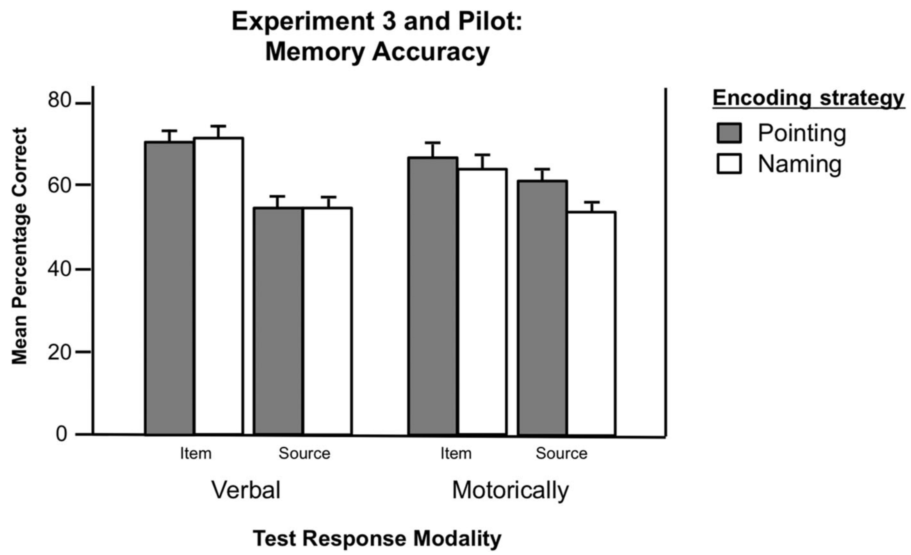

Figure 5. Item and source memory performance in Experiment 3 (test response modality = verbal) and the Pilot study (test response modality = motorically) for motorically (Pointing) and verbally (Naming) encoded picture locations expressed in percentage scores. Error bars represent standard errors: + 2 SE.

and Experiments 1 and 2, then superior source memory for verbally encoded picture locations would be expected. This finding will be further addressed in the "General discussion" section.

General discussion

The aim of the present study was to investigate whether or not manual pointing at picture locations during encoding could enhance source memory for picture-location associations in young and older adults, and whether this effect would be larger for older than young adults, because of age-related declines in source memory. Results from the pilot, Experiment 1, and Experiment 2, were in line with the first hypothesis: it was found that pointing to picture locations during encoding led to better source memory than naming (Experiment 1) and only observing (Experiment 2) the picture locations, in young and older adults. With regard to the second hypothesis, there were no indications that pointing during encoding could compensate for age-related declines in source memory. Although older adults indeed performed more poorly on the source memory test than young adults, both groups benefitted equally from pointing during encoding.

A limitation of Experiments 1 and 2 was that one could argue that the beneficial effect of pointing might have resulted result from transfer appropriate processing (Morris et al., 1977) or encoding specificity (Tulving & Thomson, 1973). Findings on these effects have shown that the overlap of the conditions, under which encoding and retrieval occur, can improve memory. Responses in the retrieval phase in Experiments 1 and 2 were made by finger tapping on the touchscreen, which was more congruent with pointing than naming or only observing. Therefore, in Experiment 3, Experiment 1 was replicated with a sample of young adults only, and participants were asked to verbally respond during the test phase instead of manually.

Interestingly, the results of Experiment 3 showed that the effect of pointing during encoding on source memory of locations, found in Experiments 1 and 2, disappeared when the locations in which pictures had been seen during encoding had to be named on the test instead of finger-tapped on the touched screen. However, there was no benefit of naming either suggesting that the beneficial effects of pointing cannot simply be explained by transfer appropriate processing or encoding specificity. So, if the findings in Experiments 1 and 2 were due to a congruency effect, then why did Experiment 3 not show superior source memory for the verbally encoded pictures? Or in other words, why would a congruency effect be specific for the motor modality?

One explanation for why pointing during encoding no longer benefits source memory performance when verbally responding, might lie in the need to translate from a perceptual memory code of the location (where the picture was seen and indicated) to a conceptual code (the word for the location), which is unnecessary when responding manually. The higher reaction times in Experiment 3 are likely to reflect this translation process. Moreover, encoding a location in space with action (pointing) enriches the perceptual (visual) memory code with a motoric memory code, which can enhance memory (Engelkamp, 1998). It is possible that pointing during encoding did not facilitate source memory performance in Experiment 3 because participants could not make use of this motoric code during memory retrieval.

Indeed, studies on enactment and symbolic gestures have shown that " … the motor coding involved in gesturing is particularly efficient for encoding information into memory and retrieving that information from memory"

(Cook et al., 2010, p. 472). For instance, a brain imaging study of recognition of action phrases learned under conditions of enactment versus reading aloud has shown that certain motor areas are activated when recognising phrases that were enacted, but not when recognising phrases that were verbalised, such as the supramarginal gyrus (Russ, Mack, Grama, Lanfermann, & Knopf, 2003), which is considered to be involved in action execution, observation, and simulation (Grèzes & Decety, 2001). Moreover, gesture production and observation has been linked to procedural memory: healthy participants who solved a physical Tower of Hanoi problem with real pegs and discs, later made different (i.e., higher arching) gestures when explaining how to solve the problem than participants who had solved the problem with a mouse on a computer, but no such effect was apparent in patients with impaired procedural memory (Klooster, Cook, Uc, & Duff, 2014). These studies seem to provide an explanation for the present findings that pointing gestures add a motoric code that benefits retrieval only when this code gets reactivated; a benefit that is lost when having to translate from procedural (and not necessarily conscious) memory to a declarative verbal code. Future research should attempt to more directly address this explanation, by combining the present experimental paradigm with the methods used by Russ et al. (2003) or like Klooster et al. (2014) testing it in clinical populations with procedural memory impairment.

Another potential explanation for the present findings might be that pointing itself did not enhance source memory performance per se, but that the positioning of the hands near the stimuli during encoding was sufficient. Evidence showed that performance on all kinds of cognitive control tasks improves if stimuli are perceived near the hands, for example, tasks targeting spatial attention (Reed, Grubb, & Steele, 2006), visual working memory (Cosman & Vecera, 2010; Tseng & Bridgeman, 2011), and executive functioning (Weidler & Abrams, 2014). These findings can be explained by the selection-for-action hypothesis (Allport, 1989), which proposes that action intentions towards objects increase attention for these objects compared with objects that people do not intend to act upon. However, the results of Experiment 3 showed that the positive effect of pointing during encoding disappeared when participants had to give verbal responses in the test phase. If the positive effect of pointing had been caused purely by hand-stimulus proximity, then we would expect the positive result of pointing during encoding to remain in Experiment 3. This suggests that merely the distance between stimuli and hand cannot explain the positive effect of pointing during encoding in the pilot, Experiment 1, and Experiment 2. Nevertheless, it would be interesting for future research to conduct a series of experiments to find out whether hand position alone can enhance spatial source memory, as to the best of our knowledge, this has not been investigated yet. In addition, another interesting direction for future research would be to investigate whether mere motor planning, without the execution of the movement itself (e.g., through mental imagery), might be sufficient to add a motor code to the memory that can enhance subsequent memory performance, and whether the specifics of the motor plan matter (e.g., object-directed versus another direction of movement). This would provide further insights into the mechanisms underlying the effects found in the present study.

A general limitation of the design was that source memory was dependent on item memory in the sense that source memory was only measured for the items recognised. Using a design, in which recognition would be tested for half of the pictures (item memory) and the location for the other half, would deal with the limitation of the present study that the source memory was tested only for the recognised pictures. On the other hand, the present study was interested in the associative memory of both the item (picture) and the source (location). Therefore, we chose to test each item on both picture recognition and location. A potential limitation of Experiment 2 was that response data of the observed pictures in the encoding phase, such as eye fixations, were not recorded, because that would change the experimental procedure too much. Therefore, we could not control whether participants attentively looked at the pictures in the observation only condition. However, participants were explicitly instructed to visually attend to all stimuli and the accuracy during the encoding of pointing was high and false pointing in the observation only condition was low. Because participants had to categorise pictures during encoding (e.g., point to the artificial pictures and only look at the natural pictures) and the pictures were presented in a random order, we can assume that the high accuracy in the pointing encoding condition and low false pointing in the naming encoding condition is evidence that participants paid attention to all pictures during encoding.

In conclusion, the present results suggest that pointing at picture locations during encoding can enhance spatial source memory in both young and older adults, but only if the response modality is congruent in the test phase. Although further research is needed to verify our explanation of this finding in terms of procedural motor memory, these results suggest that in daily life, pointing during the encoding of an object's location might be an effective strategy for motorically remembering its location at a later point of time. Because source memory declines with ageing (e.g., Bastin & Van der Linden, 2005; Bayer et al., 2011; Swick et al., 2006; Trott et al., 1999), such a strategy might be especially relevant for older people.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Notes

1. Note that correct and false responses do not add up to 100% because of a small number of misses (i.e., no response before the max. presentation time was up).
2. Note that due to a technical error, the response accuracy for named items was correctly logged for only 16 of the 39 young adult participants, so the percentage correctly named items was calculated only over these 16 participants; however, combined with the data of the pilot test, there is no reason to doubt that response accuracy was equally high for the other participants as well.

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