RUNNING HEAD: REALITY MONITORING

Reality Monitoring in Aging

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Reality monitoring is the process by which people decide whether a memory for an event was real or imagined. Whereas people can effectively discriminate between these two sources, reality monitoring errors do frequently occur. Moreover, healthy older adults and patients with probable Alzheimer's disease are more likely to make reality monitoring errors than younger adults. These errors are likely due to inefficient binding mechanisms at both encoding and retrieval as well as impaired monitoring decisions. Reality monitoring errors, especially in older adults, can lead to serious consequences such as confusing whether medications have been taken. The recent literature on reality monitoring in aging is reviewed followed by a summary of new trends in the field.

115 words

One of the largest memory-related difficulties adults face as they age is the ability to bind, relate, or associate multiple pieces of information at encoding and retrieval (e.g., Chalfonte & Johnson, 1996; Gilbert, 1941; Naveh-Benjamin, 2000). One of the first demonstrations that older adults were impaired in their ability to bind items together in memory comes from a study conducted by Gilbert (1941). In this study, Gilbert compared 174 younger adults and 174 older adults in a battery of memory tests including a paired associates task as well as a Turkish-English vocabulary task. In each of the memory tasks, including those requiring the learning of associations between a pair of items, older adults performed about half as well as younger adults. In addition, Gilbert compared the "brightest older persons" to a sample of younger adults and while this select group of older adults actually outperformed younger adults on many of the tasks, older adults still fell below the younger adults on the paired associates tasks.

Although much work has shown this associative or binding impairment in laboratory tasks, the ability to bind pieces of information is crucial for many real world tasks including reality monitoring. Reality monitoring is the process by which people separate those memories that actually happened (real events) from those only imagined or planned (Johnson & Raye, 1981). Binding comes into play because accurate reality monitoring decisions require the ability to appropriately bind episodic contextual details with the event in question. For instance, the event "taking medication" may have already occurred or may have only been imagined (or planned). According to one prominent theory, the source monitoring framework (Johnson, Hashtroudi, & Lindsay, 1993), to determine whether an event was real or imagined, one must recollect features of the event that are diagnostic of being real or imagined. Real events are commonly characterized as containing vivid perceptual details of an event whereas imagined

events contain records of thought processes (i.e., cognitive operations; Johnson, Raye, Foley, & Foley, 1981).

Is reality monitoring really a problem in aging? Do people actually forget what was real and what was imagined? In a study by Cohen and Faulkner (1989), younger and older adults were asked the frequency in which they confused actually doing something or only thought of doing it (i.e., imagined the action). Frequency ratings were made on a five point scale (*very often, quite often, occasionally, rarely, or never*). Whereas younger adults had a mean rating of 2.79, older adults (aged 72-83) had a mean rating of 2.29. The first thing to notice is that the ratings were on the left end of the scale suggesting that reality monitoring confusions are quite common. The second thing to notice is that older adults subjectively rated having significantly more reality monitoring confusions than younger adults, suggesting that the subjective frequency of reality monitoring confusions increases with age. Without the ability to effectively reality monitor, older adults may be more likely to inappropriately plan for the future or even confabulate (Fotopoulou, Conway, & Solms, 2007; Johnson, 1991). The literature investigating reality monitoring in aging will be selectively reviewed followed by suggestions as to potential unexplored research areas. Generally in the studies reviewed, the age of older adults ranges from 65-90 years old, whereas the age of younger adults range from 18-35 years old.

Literature Review

Hashtroudi, Johnson, and Chrosniak (1989) have argued that reality monitoring confusions can occur because of two reasons. First, confusions can occur because the actual memory representation is degraded. Second, confusions can occur because retrieval monitoring (or the memory decision process) is impaired. This idea is similar to the activation-monitoring framework (Gallo, 2006; Roediger, Watson, McDermott, & Gallo, 2001) in which memory

attributions, in general, are influenced by two processes: the activation of memorial representations and decision processes based on those activations. While it is difficult to determine whether reality monitoring confusions have occurred because of degraded memories or impaired monitoring processes, false alarms to new items provide insight into this dilemma. False alarms to new items implicate impaired monitoring processes because, by definition, there is no memory representation that could be degraded. Thus, for each of the studies reviewed, both reality monitoring confusions and false alarms to new items (if possible) will be discussed.

Seen and Imagined Pictures.

Some of the earliest investigations into reality monitoring confusions used simple stimuli such as seen and imagined pictures. However, only more recently have investigators started using these stimuli to investigate aging differences. Kensinger, O'Brien, Swanberg, Garoff-Eaton, and Schacter (2007) presented younger and older adults with verbal labels followed by either a picture to study or a blank square to imagine a picture of the preceding object. In addition, the objects consisted of positive, negative, and neutral items. Following seeing or imagining the objects, the participants took a source memory test in which a verbal label was presented and participants indicated whether they thought the verbal label was seen, imagined, or was never studied at all (i.e., new). The results suggest that younger adults had more difficulty distinguishing the source for items that were seen compared to items that were imagined (i.e., they were more accurate for imagined objects than seen objects). In contrast, older adults could equally distinguish the source for both seen and imagined items. Unfortunately, reality monitoring accuracy could not be directly compared between young and older adults because each group was tested at different delay intervals, thus raw differences could be due to effects of aging or testing delay.

As for the fate of the emotional items, younger adults showed increased reality monitoring accuracy for negative items compared to both positive and neutral items (for which there were no differences) whereas older adults showed no reality monitoring advantage for negative or positive items compared to neutral items. While it is unclear why imagined items had a reality monitoring advantage for younger, but not older adults, it was suggested that the reality monitoring advantage in younger adults for negative information was due to an enhancement of source-specifying details in negative information. Older adults may not share this advantage for negative information because of different processing styles in which positive information is processed equally or to a greater extent than negative information, sometimes called a positivity bias (e.g., Mather & Carstensen, 2005). As will be apparent later, this study is one of the few to use emotionally-relevant stimuli.

Another way to better understand reality monitoring in aging is to investigate confusions in unhealthy populations such as those with probable Alzheimer's disease (AD). In Barba, Nedjam, and Dubois (1999), healthy older adults and patients with AD were presented with colored drawings of common objects or were given a word of a common object and asked to imagine the object. A source memory test immediately followed the study phase. AD patients showed more reality monitoring confusions than healthy older adults. The number of correct responses for seen and imagined items was equivalent within each group of participants, however, overall AD patients were more likely to claim a previous event was "seen" than "imagined." In contrast, older adults did not show this bias. No new items were included in this experiment to directly test for monitoring impairments. However, the data does suggest that AD patients are more impaired in reality monitoring decisions compared to older adults. This impairment, in addition to lack of memory for features in each event, is also likely to be due to

an impairment in monitoring processes resulting in a bias to claim events were “seen” when they were only imagined.

In sum, after viewing or imagining pictures of objects, younger adults show better memory for imagined than seen objects, while the aging process begins to degrade memory for imaginations, resulting in equal memory for imagined and seen objects in older adults and worse memory for imagined objects than seen objects in AD patients.

Observed and Imagined Actions.

Instead of using simple picture and words to investigate reality monitoring confusions, some investigators have tried to use more realistic materials such as having participants observe or imagine simple actions. In Cohen and Faulkner (1989), younger and older adults observed the experimenter perform simple actions, performed actions themselves, or imagined performing simple actions (e.g., put the spoon next to the toothbrush). Ten minutes later, participants took a source memory test in which an action statement was presented and participants had to choose whether the action had been observed, performed, imagined, or was a new action. Overall, older adults had more reality monitoring confusions and false alarms to new items compared to younger adults. Older adults were more likely to incorrectly claim imagined items as “watched” (i.e., observed) compared to younger adults. In addition, older adults were less likely to incorrectly claim observed actions were “imagined” compared to younger adults. In other words, older adults had more reality monitoring errors for imagined actions, but less for observed actions compared to younger adults.

For new items, older adults did not differ from younger adults, but both were more likely to claim new items as “watched” than either performed or imagined (with no differences between performed and imagined attributions). This pattern for new items suggests that monitoring

processes may be spared in older adults and that reality monitoring confusions occurred because of degradations in some or all of the features found in either performed or imagined memories. In a follow-up study, Cohen and Faulkner tested the same participants with the same procedure, except at test, confidence judgments were added. Although confidence judgments did not differ between younger and older adults, confidence for memories of imagined items was lower than memories of both observed and performed actions. The results from these confidence judgments and the fact that overall hit rates for imagined items were lower in both younger and older adults suggest that memories for imagined actions may not have been very detailed.

In Fairfield and Mammarella (2009), younger adults, healthy older adults, and AD patients either watched the experimenter perform an action or imagined the experimenter perform an action. Forty-eight hours later, participants took a source memory test. The results indicate that reality monitoring accuracy was better for younger compared to older adults, and better for older adults compared to AD patients. Whereas younger adults did not differ in reality monitoring accuracy between watched and imagined actions, older adults' and AD patients' accuracy was better for watched than imagined actions. In addition, reality monitoring accuracy for imagined actions was significantly worse for AD patients compared to older adults (and younger adults).

For new items, older adults and AD patients did not differ in the amount of false alarms, but did have more false alarms compared to younger adults. Interestingly, although within younger and older adults reality monitoring accuracy did not differ between watched and imagined events, AD patients were more likely to incorrectly claim a new action was "watched" than "imagined." Overall, the results suggest that AD patients have poorer reality monitoring for imagined actions, however, this may be partially due to a monitoring deficit in attributing more

actions to being “watched” than “imagined.” This bias, evident in new items, suggests that AD patients may not utilize cognitive operations to base their reality monitoring decisions because any memorial trace is assumed to be a perceived event. This bias would explain also why reality monitoring accuracy is so low for imagined events. If there is any memorial trace, AD patients may assume that the action was “watched,” thus increasing accuracy for watched events, but decreasing accuracy for imagined events. Note that, in this study, only six AD patients were used, so it is important that this effect is replicated in a larger population of AD patients before strong conclusions are made.

In sum, for observed and imagined actions, imagined actions seem to be impaired in older adults compared to younger adults. Similarly, during unhealthy aging (AD) memory for imagined actions further decreases. This decrease is accompanied by an increased bias to misattribute new items as having been previously “seen.” These results are consistent with studies using pictures and imaginations for pictures as stimuli.

Performed and Imagined Actions.

Yet another type of stimuli used to investigate reality monitoring confusions is to have participants perform (rather than watch) simple actions while imagining other actions. One large difference in having participants perform actions rather than observing others’ actions or viewing pictures is that performing actions is a self-generated event and has been shown to include many cognitive operations. Self-generating an action is similar to self-generating an imagination, thus clouding the distinction between the two sources even further and possibly making a fundamentally different reality monitoring distinction (i.e., internal-internal discrimination rather than external-internal discrimination as is the case for perceived and imagined events).

In Hashtroudi, Johnson, and Chrosniak (1990), younger and older adults performed or imagined complex actions (mini-events) such as preparing to go on a picnic (which takes multiple steps). These events included detailed descriptions of the event including spreading a checkered napkin inside a woven picnic basket in which a bottle of red wine, a wedge of cheese, and a loaf of French bed were placed, etc. After performing or imagining a set of these mini-events, both groups of participants were asked to rate their memories for the events on numerous characteristics (also called the MCQ or memory characteristics questionnaire).

As indicated by the MCQ, older adults had subjectively fewer perceptual details, but more details about thoughts and feelings compared to younger adults. A source memory test given over the phone 3 weeks later showed that overall, younger adults had better memory accuracy than older adults and that both groups had better reality monitoring accuracy for perceived compared to imagined events (no significant interaction). No new items were presented on this test. This study provides additional evidence that, overall, reality monitoring is impaired in older adults, but further also suggests that reality monitoring may be impaired because fewer perceptual details were encoded immediately following each of the events. Hashtroudi and colleagues suggested that older adults encoded fewer perceptual details because they were attending more to their thoughts and feelings at the time instead of the actual events around them. However, if these results were due to older adults paying more attention to their thoughts and feelings (i.e., cognitive operations), then one might expect reality monitoring accuracy for imagined events to be better than performed events in older adults. However, similar to younger adults, older adults were more impaired when making reality monitoring decisions for imagined events than performed events. Perhaps older adults are attempting to pay

attention to the perceptual details, but binding processes are impaired resulting in an overall deficit in reality monitoring for both performed and imagined events.

In Mammarella and Fairfield (2006), 28 healthy older adults and 28 AD patients were asked to either perform or imagine simple actions. This study differed from most reality monitoring studies in that this study aimed to see how rehearsal during encoding of events facilitates reality monitoring decisions in a short-term reality monitoring task. They did this by having older adults and AD patients perform or imagine simple actions in a mixed list ranging from 8-14 actions. Participants were told only to remember the last 6 actions even though they did not know when the list would end. Each action was performed or imagined for 6 seconds with a 4 second interval between each action, thus making each study session range from 76 seconds to 136 seconds (about 1.5 to 2.5 min). Following each study session, a source memory test was given. This was repeated 12 times for each participant. The design of this study makes older adults discriminate between what they did and what they imagined only seconds or minutes before, thus testing what might still be held in working, or short-term, memory.

The results indicate that reality monitoring accuracy was better for healthy older adults compared to AD patients and that reality monitoring was more accurate for performed actions compared to imagined actions. One caution to note, relevant in many of these studies, is that a physical object was presented for each action whether performed or imagined, so each memory does contain some perceptual details regarding the objects involved in the action, which may lead to more attributions to calling an action “performed” than “imagined.”

For new items, which should not have this added component of perceptual details, AD patients had more memory errors than healthy older adults. In addition, both groups were more likely to call a new item “imagined” than “performed.” Overall, these findings suggest that AD

patients are worse at determining whether an action was *just* imagined or performed compared to healthy older adults, who did very well in the task. The authors suggested that AD patients may have a deficit in rehearsal and/or other encoding process that prevent features of memories for action events to be accurately bound together. Additionally, although older adults did very well in the task, they made more reality monitoring confusions for imagined events compared to performed events suggesting that features unique to imagined events may not be encoded as well as performed events in healthy and pathological aging.

In a related study by Fairfield and Mammarella (2009), younger adults, healthy older adults, and AD patients either performed or imagined actions. Forty-eight hours later, they each returned for a source memory test, thus testing for long-term memory distortions rather than short-term memory distortions in their prior study. The results indicate that reality monitoring accuracy was greater for younger adults compared to older adults and older adults were more accurate than AD patients. In addition, while younger adults equally discriminated between performed and imagined actions, older adults and AD patients both had better reality monitoring accuracy for performed actions compared to imagined actions.

For new items, older adults and AD patients had more false alarms than younger adults, but did not differ from each other. For these new items, there was also no difference in misattributions between claiming an action was “performed” or “imagined.” The authors concluded that the impairments in reality monitoring for imagined events could be due to a lack of remembered cognitive operations in aging (i.e., memories for cognitive operations are forgotten faster in aged populations) or perhaps that older adults just did not utilize cognitive operations to make their reality monitoring decisions at test. Interestingly, this effect is similar

between healthy older adults and AD patients suggesting that pathological aging may not selectively impair reality monitoring decisions, but rather create overall memory impairments.

In sum, for performed and imagined actions, older adults are impaired for imagined actions and AD patients are further impaired consistent with the previous studies using pictures and observed actions as stimuli. However, unlike the previous studies, false alarms to new items were in the opposite direction if a difference was found at all. Older and adults and AD patients were more likely to misattribute new items as having been "imagined" than younger adults. This different pattern may result from the difference in materials (i.e., self-generated actions). For example, Johnson, Raye, Foley, and Foley (1981) found that false alarms to new items were reduced after participants self-generated words compared to listening to an experimenter generate words. Johnson and colleagues argued that participants who felt that new items were familiar, but could not recollect who generated the word, inferred that the experiment must have generated the word because they would have remembered generated the word themselves (for similar generation effects, see Gunter, Bodner, & Azad, 2007; Hicks & Marsh, 1999; McCabe & Smith, 2006).

C**urrent Research Directions**

Reality monitoring confusions have also been investigated by employing the imagination inflation paradigm (Goff & Roediger, 1998). In this paradigm, participants perform and imagine simple actions similar to the studies reviewed above. However, in a second session, participants are asked to imagine the previously performed actions as well as the previously imagined actions for zero, one, three, or five times. Lastly, participants receive a memory test in which all the old actions and new actions are presented and participants have to indicate which actions were previously presented (regardless of whether they were performed or imagined) only for the first

session. If participants thought the action was presented in the first session, they were asked whether the action was performed or imagined. The key finding in younger adults is that as the number of times a participant imagines an action increases, the more likely they are to claim the action was “performed.”

This method differs from the traditional reality monitoring method in three key ways. First, participants repeatedly imagine events whereas, traditionally, they only imagine events once. Second, these additional imaginations occur for both performed and imagined events, thus memories for the events are not strictly associated with either real or imagined events. Lastly, additional demands are placed on the participants because not only do they have to remember which events were performed or imagined, but they also have to remember whether the events are from the first or second session.

Recently, the imagination inflation paradigm has been used to better understand reality monitoring confusions in healthy older adults (Thomas & Bulevich, 2006; McDaniel, Lyle, Butler, & Dornburg, 2008). In their first experiment, Thomas and Bulevich (2006) had young and older adults perform and imagine simple actions. Twenty-four hours later, participants returned and imagined both previously performed, imagined, or new actions either zero, one, or five times. Half of both younger and older adults took a memory test two days later while the other half took a memory test two weeks later. The memory test followed standard procedures for this paradigm (reviewed above). Note that the actions used were unusual or bizarre such as “kiss the frog.” The investigators wanted to minimize the spontaneous performance of those actions in participants’ day-to-day activities. Because the experiment had a long retention interval, it is quite possible that participants could actually perform simple actions such as “pick up the pen,” thus later confusing performed or imagined actions that never occurred within the

experiment. However, these results may not generalize to daily activities because bizarre events are more distinctive, thus may encourage participants to engage in additional retrieval monitoring processes (e.g., “I would have remembered doing that because the action was so bizarre”). With that in mind, Thomas and Bulevich found that after the two-day and two-week retention interval, older adults had more reality monitoring confusions than younger adults. The reality monitoring confusions reported are restricted to falsely claiming “performed” for imagined-only items (reality monitoring confusions to performed-only items were not reported). As the number of imaginations increased from zero to five, older adults were more likely to claim imagined-only actions were “performed” than younger adults. Thus, not only did this experiment replicate the imagination inflation effect in older adults, but it provided evidence that the effect is exacerbated in older adults. Both younger and older adults showed similar patterns for new items imagined during the second session.

In a second experiment, Thomas and Bulevich (2006) used the same methods as above with the exception that older and younger adults were verbally told how to make accurate reality monitoring decisions. Specifically, they were told that “memory for perceptual detail and contextual information is a useful indicator of whether an action was performed, imagined, or never presented during the first session of the experiment.” Perceptual details include how an object looked, felt, smelled, etc. Contextual information included closing one’s eyes to imagine an action or the sound of the experimenter’s voice when the action was read. Following the test, older adults were successfully able to use the instructional support to reduce their reality monitoring confusions compared to when older adults that were not given any support. This pattern was also seen for new items imagined during the second session. Despite this improvement, older adults still made more reality monitoring confusions than younger adults

when matched for retention interval. Interestingly, instructional support did not help younger adults improve their reality monitoring confusions at all, suggesting that younger adults already search memory for qualitative characteristics to help discriminate between real and imagined events.

The study conducted by Thomas and Bulevich (2006) is important because it suggests that retrieval monitoring may account for a large portion of the reality monitoring confusions found in healthy aging. By encouraging older adults to make stricter memorial judgments, they can improve their memory accuracy. However, even with this improvement their memory confusions were still larger than younger adults suggesting that the actual memories may also be less vivid or detailed than younger adults. Unfortunately, the study focused on how younger and older adults searched memory specifically for real events and even the warning instructions were more focused on the perceptual qualities of memories than other qualities such as cognitive operations. It is not known how retrieval monitoring for imagined events or how instructions for improving attributions to cognitive operations (typically associated with imagined events) may also help decrease reality monitoring confusions.

To better understand how aging effects imagination inflation for performed actions, McDaniel and colleagues (2008) conducted a similar study in which both real and imagined actions were taken into account and in which both imagined and performed actions were repeated (as opposed to only repeating imaginations). In this study, younger and older adults only imagined some actions, only performed some actions, or imagined and performed ("both" items) actions either once, twice, or four times. In a second session two weeks later, participants received all of the old and some new actions and then rated how many times (from 0 to 8) they performed and imagined each action on separate scales (resulting in two values for each item).

First, they replicated the basic imagination inflation effect in younger and older adults. In addition, as actions were repeatedly imagined (imagined-only items), they also claimed that they "performed" the actions more frequently. However, unlike in Thomas and Bulevich (2006), the imagination inflation effect was not larger for older than young adults. Similar results were found when older and younger adults repeatedly performed actions. As actions were repeatedly performed, younger and older adults were more likely to claim that the performed actions were "imagined" (i.e., a performance inflation effect). For this performance inflation effect, older and younger adults had an equivalent amount of reality monitoring confusions. This finding is interesting because it provides evidence that healthy aging does not impair one's ability to mistake real, performed actions for "imagined" actions.

Older adults' reality monitoring confusions may stem primarily from a lack of memory or inappropriate monitoring specifically for imagined items. This idea is supported by results from attributions to items that were both performed and imagined ("both" items). Younger and older adults rarely claimed that these "both" items were "only imagined" (i.e., gave a nonzero response on the imagination frequency scale, but a zero response on the performance frequency scale). In contrast, older adults were more likely than younger adults to claim "both" items were "only performed" (i.e., gave a nonzero response on the performance frequency scale, but a zero response on the imagination frequency scale). These results suggest that older adults either forgot that they imagined items at all or were biased to say they "performed" items in the event that they remembered some details, but forgot the source, which would be a monitoring error for imagined items. These results are not consistent with the previous studies involving performed and imagined actions, but rather the studies in which pictures and observed actions were used. Methodological differences may account for the discrepancy in results.

In sum, older adults' memory accuracy seems most impaired for imagined items. In addition, older adults are more likely to misattribute new items to perceptual sources (i.e., "seen" rather than "imagined"). There appears to be two likely candidates for these increased reality monitoring confusions. First, older adults monitoring for both real and imagined events are intact and working properly, but their memorial representation of either real or imagined events is impaired such that the qualitative features that are normally used to distinguish between the two types of events blur together, thus making it harder to distinguish between the two. This has been called the "dual attributions" account (McDaniel et al., 2008). A second possibility is that the memorial representations may be just as vivid as younger adults, but older adults are selectively impaired when making judgments based on imagined events because they under utilize cognitive operations as a diagnostic cue, called the "under utilization of cognitive operations" account (McDaniel et al., 2008). These accounts are not mutually exclusive and future research should be aimed to more carefully tease these apart.

Future Directions

Reality Monitoring for Simple and Complex Stimuli.

As investigations about reality monitoring have advanced, more complex stimuli have been used. The goal of creating laboratory events that are more complex is to better understand how reality monitoring confusions occur by mimicking real world events. However, have the laboratory tasks created to date accomplished the goal of creating a laboratory analog of real life? Unfortunately, all of these studies include memories that are devoid of qualities that make autobiographical memories and imaginations complex such as motivational/goal factors, emotional content, relations to one's schema for events or life script, etc. (for a similar argument, see McDonough & Gallo, submitted). As mentioned by Johnson and colleagues,

reality monitoring confusions (and source monitoring confusions, in general) are highly dependent on the types of events being compared because retrieval accuracy will depend on memorial features specific to the types of events being discriminated in memory. Using different types of materials between experiments results in a fundamentally different type of memory discrimination, which may or may not be analogous to real world reality monitoring decisions.

One way to obtain more realistic materials are by using diary studies for events that have actually happened or imaginations for events that have never occurred. After writing down many of these types of events in a diary, investigators can proceed with a source memory test. However, one of the largest criticisms against diary studies is that investigators do not have control over the stimuli. Moreover, it is unknown whether events that were once recorded as a plan or an imagination were later realized, thus becoming real events. This latter occurrence would result in an inflated amount of confusions for imagination items. Thus, a balance between real world events and laboratory control must be established.

One potential solution was recently developed by McDonough and Gallo (2008) for autobiographical memories and McDonough and Gallo (submitted) for both real and imagined events. In this task, participants were presented with an object word and asked to either retrieve a specific memory or imagine a future event cued by the object (a variant of the Galton-Crovitz technique; Crovitz & Schiffman, 1974; Galton, 1879). After retrieving each memory or imagining each future event, participants were asked to rate each event on numerous features such as perceptual details and cognitive operations, among others. Similar to the study conducted by McDaniel et al. (2008), participants both retrieved a past memory and imagined a future event for some of the cue words. The next day, participants received two tests: an autobiographical memory test (for real, past events) and a future imagination test (for imagined, future events).

This task advanced the traditional methods to investigate reality monitoring in three ways. First, real past and imagined future events with all their complexity are used with the control that each one is tied to a different specific cue. Second, "both" items were used forcing participants to search memory for features that are diagnostic of one source at a time (diagnostic monitoring; see Gallo, Weiss, & Schacter, 1994). In other words, in many of the past reality monitoring tests, subjects can use multiple retrieval strategies to infer whether an item was real or imagined other than using perceptual features to infer the occurrence of a real event or cognitive operations to infer the occurrence of an imagined event. More specifically, subjects can use a recall-to-reject strategy (or exclusion strategy; see Gallo, Cotel, Moore, & Schacter, 2007) such that if a subject believes the item was presented earlier and was not an imagined item, then it must have been "seen" (the it-had-to-be-you effect; Johnson et al., 1981). Third, because reality monitoring is tested using different retrieval orientations (i.e., orienting towards the past or the future), monitoring and activation processes can be independently measured for real and imagined items. Better understanding of how monitoring and activation independently affect reality monitoring confusions is crucial in aging because it has been hypothesized that aging may cause selective impairments in monitoring for imagined events and not for real events (under utilization of cognitive operations hypothesis). Unfortunately, only younger adults have been tested with this paradigm. Thus, future research should take advantage of the methodological strengths of this design to better understand the effects of aging.

Reality Monitoring for Different Types of Events (Past versus Future).

As mentioned above, one new avenue being explored is reality monitoring for past compared to future events rather than compared to atemporal imaginations (imaginations that are not concerned with a specific time). Although differences between future imaginations and

atemporal imaginations have not been thoroughly investigated, it may be that future events contain unique diagnostic features that are absent in atemporal imaginations. For instance, future events may be unique because they are often related to one's personal goals, life scripts, and are emotional. Often times when reality monitoring confusions are made, it is because one planned to accomplish a certain action (future imagination) and sometimes actually realize these planned actions (real past event), but other times these plans go unrealized. Do reality monitoring confusions decrease when past memories are compared to future imaginations as opposed to atemporal imaginations? How might these differences affect reality monitoring confusions in older adults? Unfortunately, we do not yet know. However, at least in younger adults, it appears that memory accuracy for future events is better than for past events (McDonough & Gallo, submitted). These results are in contrast to those usually found for atemporal imaginations in which memory accuracy is usually better for real events. McDonough and Gallo (submitted) argued that cognitive operations may be weighed more when making reality monitoring decisions, thus allowing for better reality monitoring accuracy for these future events. They also argued that this finding is in line with the constructive episodic simulation hypothesis (Addis, Wong, & Schacter, 2007; Schacter , Addis, & Buckner, 2008), which suggests that the function of memory may be to imagine, or simulate, future events. If imagining future events is the ultimate goal of memory, then it may be the case that it is more adaptive to know what actions we have not done so that we can still accomplish them at a later point (Suddendorf & Corballis, 1997). Would similar future-oriented memory accuracy be obtained with older adults as well? Possibly, however an alternative hypothesis is that we have evolved to adapt differently as we age and may have better memory for past events to help advise the young and inexperienced.

Neuroimaging for Reality Monitoring Processes in Aging.

The idea of comparing past and future events was inspired by a recent surge of neuroimaging studies showing a large overlap between brain regions when remembering the past and imagining the future, suggesting that the same core network is responsible for both types of processes (for review, see Schacter et al., 2008). If the neural substrates between remembering the past and imagining the future are so similar, then how are the two events discriminated in memory? Whereas there are no studies investigating reality monitoring confusions in older adults using neuroimaging techniques, there are a few in younger adults (Kensinger & Schacter, 2005, 2006; Okado & Stark, 2003). These studies converge with behavioral studies showing that memories for real (perceived events) are supported by neural activations in regions supporting perceptual reactivation including occipital regions, parahippocampal gryus, and the fusiform gyrus whereas memories for imagined events are supported by neural activations in regions supporting cognitive operations including ventromedial frontal cortex and the posterior cingulate. Interestingly, misattributions have commonly resulted in activity in the anterior cingulate perhaps owing to processing vivid mental images (Kensinger & Schacter, 2005). The anterior cingulate has also been implicated in discrepancy detection and error detection (Eisenberger & Lieberman, 2004). Thus, activity in this region may be active when participants are unsure of whether an event was real or imagined.

Research on the neural correlates of aging have suggested that prefrontal and medial temporal regions are impaired in older compared to younger adults (e.g., Persson, Nyberg, Lind, Larsson, Nilsson, et al., 2005; Rabbitt & Lowe, 1999). These findings are consistent with the overall findings that older adults' memory for imagined items is impaired (which is thought to rely on prefrontal cortex through the use of cognitive operations) or that monitoring processes may be impaired (which is also thought to rely on the prefrontal cortex). However, hippocampal

deterioration has also been found as a function of healthy aging suggesting that memory activation and/or binding deficits may also contribute to reality monitoring confusions (e.g., Persson et al., 2005; Rabbitt & Lowe, 1999), thus adding to the complication of determining the origins of reality monitoring confusions in older adults. Neuroimaging research on reality monitoring confusions in older adults could help clarify why older adults seem to be more susceptible to these confusions.

Concluding Remarks

Clearly, older adults have more reality monitoring errors than younger adults. The studies reviewed converge on the idea that memories for imaginations are impaired as age increases. However, the mechanisms underlying this memory impairment has been difficult to identify because both activation and monitoring processes contribute to reality monitoring decisions and one or both of these may be impaired as a function of aging. The issue is further complicated because different types of stimuli lead to different patterns of memory errors. For instance, reality monitoring paradigms using performed/imagined actions sometimes lead to reality monitoring errors in the opposite direction compared to when using observed/imagined actions. New advances in methods and neuroimaging techniques have potential to extend our knowledge of reality monitoring in aging.

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