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Situation Awareness and Older Workers

Cheryl A. Bolstad and Thomas M. Hess
North Carolina State University - Department of Psychology

Introduction

Since 1900, there has been a "graying of America", with the average age of the population steadily rising. Older adults (over age 65) now comprise over 13% of the population, as compared to 4% in 1900, and this number is projected to be 20% by the year 2030 (Moody, 1994). During the next two decades, population growth will be concentrated among those individuals over the age of 50 as the baby boomers will become senior citizens. Along with this shift in the population structure is an increasing concern with the capabilities of and problems faced by older adults, especially given that a decrease in the size of the workforce and changing retirement practices may lead to greater levels of employment of older adults than seen in the past.

Although typically studied in younger adults, we would like to argue that the study of Situation Awareness (SA) may be a useful way of assessing the specific problems faced by older workers. Obviously, SA is just as important for older and middle-aged adults as it is for younger individuals and future research in SA needs to address these populations. This is especially true now that SA work is being conducted outside of the military, such as in nuclear power plants and air traffic control towers, where the subject population is likely to be more heterogeneous and SA acquisition in older adults may be more of a concern. We would also like to argue that the study of SA is not just useful for work-related activities, but in everyday situations as well. For example, SA is as important to the older adult trying to cross a busy street as it is to a young pilot trying to shoot down the enemy. In both situations a life may be lost, but good SA could lead to more positive outcomes. Thus, the formation of SA may be critical to continued well-being and adaptive functioning in older adults.

The study of aging and SA may present unique problems to researchers. Presently, most of the theoretical work on SA and its measurement methods rely on studies in which the subject population consists either entirely of college students or young military pilots. Due to cognitive changes that may begin occurring during the middle years of a person's lifetime, however, both the formation and assessment of SA could be affected. Age-related changes in cognitive capabilities and experience may force us to examine current operationalizations of SA and their applicability to different age groups. It is the goal of this paper to examine aging-related cognitive changes that may affect a persons' ability to acquire SA. Whereas we will not address specific SA measurement methodologies, much of what we have to say will have implications

for the assessment of SA across the adult lifespan.

Endsley's Theory of Situation Awareness

There are several theories that describe the formation of SA (e. g., Endsley, 1995; Adams, Tenney, and Pew, 1995). While each take different perspectives, they embrace some of the same ideas. For present purposes, however, we felt it was useful to examine age-related cognitive changes and SA acquisition within the context of one model that addresses information processing since much of the research on cognition and aging has been done within this perspective. For this reason, we chose Endsley's (1995) theory because of its close link with information-processing theory, which in turn should facilitate our development of hypotheses about aging. Endsley proposes that situation awareness is comprised of three hierarchical phases. These phases form the primary components of her definition of SA.

> Situation awareness is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future (Endsley, 1988).

Each of the phases of Endsley's definition of SA will be addressed below and how age-related cognitive changes may affect their formation.

Level 1 SA

Currently, it is accepted that one of the first steps towards the formation of SA is the perception of information within a given situation (Salas, Prince, Baker, and Shreshta, 1995). It is this active perception that allows individuals to extract important components from their environment (Dominguez, 1994). Endsley (1988, 1990, 1995) refers to this state as Level 1 SA: "The perception of the elements in the environment within a volume of time and space .." The individual perceives the elements by selectively attending to the incoming stimuli. Through this selective attention, important/essential information is attended to while nonessential items are disregarded.

As we age, certain aspects of our ability to selectively attend to information decline (for a review, see Plude, Schwartz and Murphy, in press). This is especially true in situations where the target information competes with other information in the environment. One problem that older adults have has to do with their ability to inhibit non-selected information. Relative to younger adults, older individuals may have more difficulty suppressing or inhibiting unattended information. This has the effect of limiting working-memory resources as precious capacity is taken up by irrelevant information (Hasher and Zacks, 1988). Studies have also shown that selective attention is negatively affected by aging when the individual must engage in visual search. Basically, older adults exhibit disproportionate increases in time to search for a visual target as the number of items in the visual array increases. Finally, such effects are not just limited to the visual domain. Research has also shown that aging has a negative impact on the

ability to actively filter or select out information from multiple sources in the auditory domain. This is especially true in tasks that place a heavy demand on the limited attentional capacities of a person. For example, a familiar auditory selection task includes the "cocktail party phenomenon," in which a person can selectively attend to many of the conversations going on around the room while ignoring others. Relative to younger adults, older adults demonstrate a greater susceptibility to interference in some situations when compared to younger adults (Barr and Giambra, 1990). In essence, then, studies of attention in aging have demonstrated that older adults have problems in selecting information from the environment when they must search the environment and when the amount of irrelevant or competing information is great.

While studies have shown that some aspects of selective attention decline in later life, this does not appear to be the case in every situation. When environmental support in the form of distinctive cues and preexisting information regarding spatial location are available to an adult, they can overcome many of these problems (Plude et al., in press). In addition, it should be noted that the problems just noted typically occur within novel contexts (e.g., standard laboratory tasks). In situations where the subject has expertise, many of these effects may be greatly reduced or eliminated as demonstrated in several studies of expertise that use domain-specific tasks (e.g., Morrow, Leirer, Fitzsimmons, and Altieri, 1994). Experts have the ability to activate appropriate schemas from long-term memory to aid in performance in domain-specific tasks. The schemas allow them to focus their attention on the appropriate information as well as help direct their attention to where information may be presented through use of probabilistic information. These schemas also aid in the inhibition of irrelevant, nonessential items.

Thus, if SA is measured using experts for the given situation, as it currently is, attentional deficiencies associated with aging may not be much of a concern. If and when SA is measured for novices, however, these decrements may play a part in a persons' formation of SA. It should be noted also that the ability of certain tests to predict one's ability at SA formation may be age-related. For example, if standardized tests assessing individual differences in basic skills thought to be associated with the formation of SA are used in selection or performance assessment, older experts may be penalized by their poor performance on content-free tasks. The inability of such tests to assess performance in context would be an important concern in any attempts to promote their use.

Level 2 SA

Once individuals have perceived the information in the environment, the next step is to integrate and comprehend the information in working memory (Salas et al., 1995). The information is brought into consciousness, thus allowing the person to meld the information into a coherent picture (Dominguez, 1994). Endsley (1988, 1990, 1995) refers to this state as Level 2 SA: "..the comprehension of their (elements) meaning". Many authors refer to this "product" of SA as a mental model. It is the elements in the environment that a person perceives which activate the schemas in working memory and updates their mental model (SA) (Dominguez, 1994). In essence, they use their mental models/schemata from long term memory to enhance/clarify the situation (Salas, et al., 1995). However, SA is temporal in nature and this process would need to be continuous in order for a coherent picture of the situation to remain.

It is this Level 2 SA that may be the most troublesome for older adults. While older individuals may have no difficulties perceiving relevant elements within the environment, they may have problems retrieving this information from memory as well as perceiving from where it came. Many researchers believe retrieval problems are due to the incomplete encoding of contextual information in the first place. Studies have shown that there is an age-related impairment in the processing component concerned with the retrieval of information from memory (Salthouse, 1992).

In addition, once information is activated in memory, older adults may have difficulty identifying the source of the information and, thereby, discerning both where the information came from and what actually occurred versus what was inferred from existing schemas. An example of this type of problem is clearly demonstrated in studies of false fame (e.g., Jennings and Jacoby, 1993), where older adults are more likely than younger adults to misattribute fame to nonfamous but previously viewed names because they have difficulty identifying the source of their feelings of familiarity. In general, age has a more negative effect on memory in situations involving conscious recollection processes (i.e., direct tests) than in those involving automatic retrieval (i.e., indirect tests) (Howard, in press). Interestingly, it might be hypothesized that experts would be more susceptible to false familiarity problems associated with aging than would be novices. Experts possess many mental models of various situations and may have difficultly discerning between what actually occurred and what was activated in their memory by these models.

Such problems may prove particularly troublesome in situations where it is important not only to be aware of information essential to SA, but also to know the origins of such information. Through the operation of automatic encoding and retrieval processes, older adults may have much of the same information available to them as younger adults. However, as Endsley (1995) points out, it is important in many situations to be able to identify not only what information is available, but how this information became available. Uncertainty about the validity of the information used in SA formation may result in the construction of more tenuous mental models that may have a negative impact on decision making. The automatic processing associated with many scenarios may result in problems for individuals of all ages, but these problems may be exacerbated with age as the ability to consciously control and monitor working memory processes suffers.

Thus, Endsley's Level 2 SA has the greatest potential to be effected by age related changes. This may be especially apparent when using many of the SA measurement methods. In particular, explicit tests of SA will be the most affected as these directly test an individuals' SA. While expertise may be able to negate some of these more negative effects associated with aging, older novices, will be at a disadvantage relative to younger novices.

Level 3 SA

As we have noted, changes in cognitive abilities with age may have important consequences on the formation of Level 1 and Level 2 SA, but what happens to Level 3 SA?

Endsley (1988, 1990, 1995) refers to Level 3 SA as the "..the projection of their (elements) status in the future." Through the comprehension of the activated schemata, the individual is guided in their projection of future status as well as their selection of future actions (Endsley, 1995).

Both Level 2 and Level 3 SA involve the continuous extraction and updating of information from working memory. Numerous studies have shown that working-memory capacity and the efficiency of associated processes declines with age (Salthouse, 1991; Salthouse and Babcock, 1991). It may be this decline in working memory capacity that has the greatest effect on Level 3 SA. As we have already noted, these problems in working-memory functioning are most evident in tasks that require a great deal of deliberate, conscious processing (Smith and Earles, in press). Age-related limitations in working-memory processes may lead to difficulties in gaining a coherent picture of the environment as well as making future projections since it can be reasonably assumed that at least some aspects of these functions require deliberate processing. For many experts, many of these processes may be automatic. Thus, with extensive practice, older adults may be able to compensate for some of their working memory declines as they develop automaticity of a skill (Bosman and Charness, in press). Endsley (1995) also believes that attentional limitations can also be somewhat overcome through automaticity of a skill. Such optimism may have to be tempered, however, based on evidence that age may even limit the development of automaticity in certain types of situations (e.g., Rogers, Fisk, and Hertzog, 1994).

Conclusion

The age-related cognitive changes affecting the formation of SA that we have discussed above exhibit a great deal of interindividual variability. Therefore, not all middle-aged or older individuals will exhibit these changes, nor will they be affected in the same manner. However, researchers in the area of SA, particularly in fields were SA may be studied with novices, should be aware of these cognitive changes. They can not only affect the formation of SA, but they can influence the utility of many measurement methods.

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