How Use of GPS Tools Impacts Spatial Awareness and Cognitive Mapping in Younger Generations

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Research Problem

GPS has become an integral part of everyday life, offering turn-by-turn directions that reduce the need for active engagement in navigation. Whether commuting to work, running errands, or traveling to new locations, people now rely heavily on their smartphones or vehicle navigation systems to handle routing and directions. While this convenience has made travel more efficient and reduced the cognitive load associated with map reading or route planning, it has also diminished the necessity for individuals, especially younger people, to develop essential navigational skills that were once considered part of growing up.

This reliance on GPS may have unintended cognitive consequences. Navigation involves spatial reasoning, a skill linked to the brain's hippocampus, which is crucial for memory and orientation. Research suggests that regularly engaging in tasks that challenge spatial awareness, such as reading maps or mentally visualizing routes, helps maintain cognitive flexibility and may even protect against age-related conditions like Alzheimer's disease. When people grow up without developing these skills, there may be long-term implications for their brain health and resilience. This makes it important to study how digital navigation tools might be reshaping not just how we move through the world, but also how our brains develop and function over time.

The social impact of widespread GPS reliance extends beyond individual cognitive effects, influencing how people interact with their environment and each other. As navigation becomes more automated, opportunities for shared experiences, like planning routes together, asking for directions, or exploring unfamiliar areas, are

diminished. This can reduce the development of communal knowledge about local geography and weaken the sense of connection to one's surroundings. For younger generations, the lack of spatial engagement may contribute to a more passive relationship with their environment, leading to a decline in confidence and independence when navigating without technology. Over time, this shift could impact how communities function, eroding the informal social networks and local knowledge that often emerge through shared navigation and exploration.

This paper intends to investigate what the current literature shows pertaining to how various navigation methods impact an individual Specifically focused on how younger generations have been and will be impacted by the increased use of GPS instead of traditional way finding methods.

Literature Review

A study by Dahmani and Bohbot (2020) looked at 50 drivers by assessing their experiences with GPS throughout their lives and various aspects of spatial memory. They specifically looked at spatial memory use strategy, cognitive mapping, and using virtual navigation tasks to evaluate landmark encoding. They found people who have used GPS more throughout their lives have worse spatial memory when navigating without GPS. 13 participants were retested after 3 years which showed that more GPS use correlated with a sharper decline of spatial memory (Dahmani & Bohbot, 2020).

Participants were aged between 19 and 35, right handed, had no history or neurological or mental disorders, had no history of alcohol or drug use, and no head trauma that caused them to be knocked out. People who were not regular drivers, and other outliers were excluded from the study (Dahmani & Bohbot, 2020).

The discussion session addresses whether a decline in spatial memory causes increased GPS use or vice versa. They found no association between a participant's sense of direction and the amount of GPS use. There is a short discussion about how different forms of wayfinding are more prevalent in different cultures where GPS could lead to taking more dangerous routes. No discussion concerning younger generations was mentioned in this study (Dahmani & Bohbot, 2020).

In a separate study, Bohbot et al. (2007) tested 30 young people by having them explore a virtual maze and completing various tasks. MRI's were then conducted to look at grey matter differences.They found that people who used spatial memory strategies had increased activity in the hippocampus and response strategies resulted in activity in the caudate nucleus. In other words, spatial learners had more grey matter in the

hippocampus and less in the caudate nucleus whereas the opposite was true for response learners (Bohbot et al., 2007).

The discussion explores how different strategies can be more optimal in different situations, but the effect the different strategies have on the location of grey matter is important to consider since low grey matter in the hippocampus is a risk factor for alzheimers. They did find that good navigators were able to adjust which strategies they use. Clinical intervention programs that help to adjust the strategies a person uses could be helpful for people recovering from brain injuries or alzheimers to better utilize their intact memory systems and to protect against degeneration of the hippocampus later in life (Bohbot et al., 2007).

Jarvis, Kraftl, and Dickie (2017) conducted a study involving 122 children between the ages of 9 and 16 engaged with GPS tracking and Google Earth as tools for exploring their daily movements. After carrying GPS devices for a week, children viewed their movement data overlaid on Google Earth imagery during semi-structured interviews. Many participants were able to accurately identify familiar locations, detect errors in the GPS data, and interpret complex map elements such as scale, patterns, and built environments. These findings revealed not only technical spatial literacy skills but also a higher level of critical thinking—such as questioning data accuracy and recognizing discrepancies in satellite images (Jarvis, Kraftl, & Dickie, 2017).

The study emphasizes that children's spatial literacy is deeply intertwined with memory, emotion, and daily experience. For instance, reviewing GPS traces often triggered vivid recollections of events, people, and routines. Children shared stories about family visits, games with friends, and even shortcuts passed down from parents

and grandparents. These personal narratives demonstrated that spatial learning is not isolated from lived experience but embedded in the social and emotional fabric of everyday life. The use of digital maps in this context served as both a memory aid and a tool for expressing a child's connection to place (Jarvis, Kraftl, & Dickie, 2017).

Unlike traditional spatial ability tests that occur in controlled environments, this research highlights the value of qualitative, context-rich methods to understand spatial literacy. The authors argue that interactive and reflective engagement with mapping tools like Google Earth can enhance spatial understanding rather than diminish it. This challenges assumptions that GPS use always weakens spatial cognition and instead suggests that the way these tools are used—passively or actively—plays a critical role in shaping cognitive outcomes (Jarvis, Kraftl, & Dickie, 2017).

All three studies show that GPS and navigation strategies have a real impact on how people develop and use spatial memory. Dahmani and Bohbot (2020) found that people who rely on GPS more often tend to have worse spatial memory, especially when navigating on their own without it. Bohbot et al. (2007) backed this up by showing that people who use spatial strategies—like remembering landmarks or visualizing routes—have more gray matter in the hippocampus, which is important for memory. On the other hand, people who use response strategies, like following turn by turn directions, rely more on the habit forming part of the brain called the caudate nucleus. This part of the brain helps with routines and automatic behavior, so instead of building a flexible mental map, they're basically running on autopilot. But the study by Jarvis, Kraftl, and Dickie (2017) complicates the idea that GPS is always harmful. They found that when kids used GPS and Google Earth in an active, reflective way, it actually

helped build spatial thinking and made them more aware of their surroundings. They didn't just follow directions—they talked about their routes, shared memories, and made sense of where they had been.

Research Question

How does frequent GPS usage affect the spatial awareness and natural navigation ability of younger generations, and what are the potential societal consequences of this shift in cognitive behavior?

Research Design/Methods

The widespread use of GPS technology among younger generations has brought notable social and technical consequences. Socially, the reliance on GPS has contributed to a decline in traditional navigation skills, such as reading maps, understanding cardinal directions, or using landmarks for orientation. Many young people now depend almost exclusively on turn-by-turn directions, often resulting in reduced spatial awareness. This can lead to situations where individuals can navigate a route only with digital assistance, making them vulnerable in areas with poor signal or when technology fails.

Another social impact is the diminished opportunity for developing problem-solving and critical thinking skills that naturally arise from navigating unfamiliar environments. In earlier times, getting lost and finding one's way back required attention

to surroundings, asking for help, and interpreting physical cues; all valuable social and cognitive experiences. With GPS, these scenarios are often bypassed, potentially stunting the development of adaptive, independent decision-making abilities. Furthermore, the heavy use of GPS reduces interactions with locals, which could otherwise foster community engagement and cultural learning, especially when traveling.

On the technical side, overdependence on GPS poses significant risks in terms of data reliability and privacy. GPS systems are not infallible; they can deliver outdated, incorrect, or unsafe route information due to mapping errors or software bugs. Younger users, trusting the technology implicitly, may follow unsafe routes or ignore better judgment. Additionally, many GPS enabled apps collect detailed location data, which can be stored and shared, raising concerns about personal privacy, surveillance, and data misuse. These technical vulnerabilities are often underestimated by users who see the convenience of GPS but are unaware of its underlying risks.

Additionally, the integration of GPS into nearly every aspect of mobility, from ridesharing to fitness tracking, fosters a digital ecosystem where location data becomes a critical asset. This increases pressure on infrastructure and exposes society to broader cybersecurity threats. If GPS services are disrupted due to technical failure or malicious attack, those heavily reliant on it, especially the younger demographic, may be disproportionately affected. Balancing convenience with caution and encouraging geographic literacy alongside technological fluency is essential to mitigate these long-term social and technical consequences.

Scientific studies and reputable published research articles will be the primary source used. We also have a book that inspired our topic that will be a wealth of information and provide further sources that have investigated our topic. The reason we've chosen to primarily focus on scientific studies looking into the neurological effects of GPS use is because these aren't anecdotal. They provide actual evidence of the impact GPS use can have on a person. We want to look for as much relevant and modern research that's been conducted. We will also look at the results of the studies. If the study design was flawed, then the results might not hold as much weight. So it'll be important to understand how the studies were conducted to ensure our analysis and synthesis of everything we've read is rationalized properly. In general, we'll be looking to make sure the sample sizes are not too small, see if they're potentially replicable, and check for any conflicts of interest that could have influenced their outcomes.

Conduct Research

In the paper "How is GPS used? Understanding navigation system use and its relation to spatial ability" by Alexis Topete, the researchers looked to answer three questions. How is GPS use and dependency related to participants' self-reported sense of directions and spatial anxiety? How is GPS used and how do people adjust GPS usage depending on how familiar they are with their navigation goal? And thirdly, how is GPS dependency and use related to objectively measured sense of direction? The study used two methods to answer these questions. They had an online study and an

in-person study. The online study used data pulled from 200 participants and the in-person study measured 67 participants.

The overall study found that GPS dependence is negatively correlated with the participants' performance in navigation tests and their self-reported sense of direction. GPS dependence was positively correlated with self-reported spatial anxiety. The study also found that those who reported a poor sense of direction and more spatial anxiety also used GPS more often for turn-by-turn directions. And, similar to other studies, they found that people will adjust how they use GPS depending on the situation.

The age range of the participants in this study ranged from 18-32 years old, but the mean age was 19.67, showing most of the participants fell on the lower end of the age range. So even though this study doesn't directly tie the participants' test results to their age, it does show the overall trend in how GPS is used in younger demographics. It's important to understand how younger generations use GPS in their daily lives in order to get a better idea of how widespread any negative consequences of GPS use could be. The information provided from this paper builds the foundation of understanding why this issue needs further scrutiny.

In a study conducted by Ruginski, Creem-Regehr, Stefanucci, and Cashdan (2019), researchers looked at how frequent GPS use might affect a person's ability to learn and remember new places. They recruited 201 university students who completed a virtual navigation task, a mental rotation test, and a perspective-taking assessment. Participants also self-reported how often they used GPS devices and rated their navigation ability. The virtual task involved exploring a simulated college campus and

then completing map-based tasks such as landmark pointing, distance estimation, and cognitive map creation. These tasks assessed participants' ability to build an internal spatial representation—referred to as environmental learning (Ruginski, Creem-Regehr, Stefanucci, & Cashdan, 2019).

The study found that frequent GPS users performed worse on both mental rotation and perspective-taking tasks. These two spatial abilities are essential for transforming spatial information in one's mind, such as imagining an object from another viewpoint or navigating from a different orientation. The researchers used structural equation modeling that showed the effect of GPS use on environmental learning was fully mediated by these spatial transformation abilities. In other words, GPS users learned less about the environment primarily because their mental rotation and perspective-taking skills were weaker. These effects remained even after accounting for participants' self-reported sense of direction and travel habits, suggesting GPS use itself plays a unique role in reducing spatial skills (Ruginski, Creem-Regehr, Stefanucci, & Cashdan, 2019).

The authors conclude that over-reliance on GPS technology may hinder the development or maintenance of cognitive processes vital for navigation. They suggest that using GPS may reduce the need to mentally transform spatial information, which over time could degrade these abilities. The study shows a strong link between frequent GPS use and weaker spatial thinking skills. Future research could look into whether certain kinds of GPS design or navigation training can reduce these negative effects and help keep spatial transformation abilities sharp. (Ruginski, Creem-Regehr, Stefanucci, & Cashdan, 2019).

GPS is something most of us rely on almost every day. It's convenient, fast, and honestly hard to imagine going somewhere new without it. But in this article Road to Madness: Truth Behind Dangerous Effects of GPS, Divya Sivalenka (2023) talks about how this constant use of GPS might be changing the way our brains work, especially when it comes to how we find our way around.

She points out that GPS use has been linked to a decline in spatial memory, which is the mental skill we use to remember places and how to get from one location to another. The article references a 2017 study that found people who used GPS more often had worse performance on tasks that required them to remember routes without digital help.

Sivalenka also talks about how GPS affects something called spatial transformation. That's the ability to picture how things are arranged in space and mentally rotate them. Because GPS gives us step-by-step directions we don't really need to build that skill anymore. Over time this could make it harder to understand where we are in relation to our surroundings or to learn a new city without help.

The article also includes some student opinions and a quote from writer M.R. O'Connor who says using our own perception and problem-solving to navigate helps us feel more connected to a place. GPS on the other hand, keeps us stuck on a screen and unaware of the changing world around us. While one student said that people tend to overreact about tech, the overall message is not that we need to get rid of GPS entirely, but that we should balance it with traditional skills like reading maps or paying more attention to landmarks.

Findings

Recent research has highlighted the complex relationship between GPS usage and spatial memory, revealing both cognitive benefits and potential drawbacks. Studies by Bohbot et al. (2007) and Konishi and Bohbot (2013) have demonstrated that individuals employing spatial navigation strategies, such as using environmental landmark, tend to have greater gray matter volume in the hippocampus. This brain region is crucial for spatial memory and cognitive mapping. Conversely, those relying on response strategies, which involve repeating learned sequences of movements, show increased gray matter in the caudate nucleus. Notably, a negative correlation exists between gray matter volumes in these two regions, suggesting a competitive interaction (Bohbot et al., 2007).

In contrast, extensive use of GPS has been associated with declines in spatial memory. Dahmani and Bohbot (2020) found that habitual GPS users performed worse on spatial memory tasks during self-guided navigation, even when they did not report poor navigational skills, which was similarly reported in other research (Topete, *et al.* 2024). This decline was linked to decreased hippocampal-dependent spatial memory. Further, Ruginski et al. (2019) proposed that GPS use negatively impacts environmental learning by impairing spatial transformation abilities, such as mental rotation and perspective-taking. These abilities are essential for forming cognitive maps and navigating unfamiliar environments.

The interplay between navigation strategies and brain structure underscores the importance of engaging in spatial navigation to maintain cognitive health. Jarvis, *et al.* (2017) highlighted how spatial literacy is also deeply linked to memories, emotions and daily experiences and the way GPS tools are used is what determines whether or not the impacts will likely be negative or positive. While GPS devices offer convenience, overreliance may hinder the development and maintenance of spatial memory skills. Encouraging practices that promote

spatial awareness, such as navigating without GPS or using maps, could be beneficial for cognitive longevity.

The findings address our research question, revealing significant impacts of GPS use on spatial awareness, navigation ability, and broader societal consequences. Frequent passive GPS use notably diminishes younger generations' spatial cognition, potentially leading to reduced cognitive flexibility and independence. Neurologically, consistent GPS reliance restructures cognitive pathways, emphasizing the risk of long-term cognitive impairment. Conversely, active GPS interactions show promise in mitigating these negative outcomes, indicating the need for educational and technological strategies to encourage reflective and interactive engagement with digital navigation tools. Societal impacts further underscore the importance of maintaining navigational skills to foster stronger community connections and preserve communal knowledge, highlighting that balanced and strategic use of GPS technology is critical for both individual cognitive health and societal well-being.

Conclusions

In conclusion, the research strongly suggests that frequent GPS usage is having a detrimental effect on the spatial awareness and navigational abilities of younger generations. The evidence reviewed points to a growing concern: that the convenience and reliability of GPS technology may be coming at the cost of essential cognitive skills. Studies such as those by Dahmani and Bohbot (2020) and Topete et al. (2024) clearly show that there is a measurable decrease in spatial memory as GPS reliance increases. This decline is not just behavioral, but also neurological, as demonstrated by the corresponding reduction in grey matter within the hippocampus; an area of the brain closely associated with memory, spatial reasoning, and learning. These findings make it clear that our increasing dependence on digital navigation tools

may be reshaping our brains in ways that make us less capable of functioning independently in physical space.

Further evidence by Ruginski et al. (2019) reinforces this concern by showing that other key spatial skills, like mental rotation and perspective taking, are also negatively affected by regular GPS use. These abilities are crucial not only for navigation, but also for broader cognitive functions such as problem solving, orientation, and even social understanding. When these skills are underdeveloped or degraded, individuals may experience a broader range of difficulties beyond simply finding their way from point A to point B. For younger generations, who have grown up with GPS as a constant presence, there may be long-term developmental implications that are only beginning to be fully understood.

Ultimately, if younger generations continue to depend on GPS without engaging in active navigation themselves, there is a real risk that they will lose the ability to move confidently and independently through the world. The challenge lies not in rejecting technology, but in learning to use it wisely. The goal should be to find a balance; one that allows individuals to enjoy the benefits of GPS without sacrificing the cognitive skills and emotional experiences that come from real-world navigation. Without this balance, the long-term costs to brain function, memory, and personal connection to place may outweigh the short-term convenience GPS provides.

Recommendations

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