# Appendix A: SAGAT Studies – Sensitivity Analysis

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Paper** | **Domain** | **Environment** | **Subjects** | **Number** | **Measure** | **Scoring** | **Sensitivity** | **Correct method** | **Findings** |
| **(Alexander & Wickens, 2005)** | Aviation | Simulation | Experienced | 24 | SAGAT | By Query | 0 | 0 | Not sensitive to display conditions |
| **(Barnes, McDermott, Hutchins, & Rothrock, 2011)** | Military | Microworld | Students | 48 | SAGAT | Combined | 1 | 0 | Sensitive to display conditions |
| **(Blömacher, Nöcker, & Huff, 2018)** | Driving | Video | Experienced | 120 | SAGAT | By Level | 1 | 1 | Sensitive to automation descriptions and experience with system |
| **(Bogossian et al., 2014)** | Medical | Live Exercises | Novice | 97 | End of trial queries | Combined | 1 | 0 | Sensitive to training location |
| **(Bolstad & Endsley, 2003)** | Military | Simulation | Experienced | 25 | SAGAT | By Query | 1 | 1 | Sensitive to team differences |
| **(Bolstad, Cuevas, Gonzalez, & Schneider, 2005)** | Military | Live Exercises | Novice | 17 | SAGAT | Combined | 1 | 0 | Sensitive to training conditions |
| **(Bolstad, Endsley, Costello, & Howell, 2010)** | Aviation | Simulation | Experienced & Novice | 48 | SAGAT | By Query | 1 | 1 | Sensitive to training conditions |
| **(Bowden & Rusnock, 2015)** | Process control | Simulation | General | 24 | SAGAT | By Level | 1 | 1 | Level 3 SA sensitive to display conditions |
| **(Buchler et al., 2016)** | Military | Simulation | Experienced | 213 | SAGAT | Combined | 1 | 0 | Sensitive to information sharing frequency and patterns |
| **(Burns et al., 2008)** | Process control | Simulation | Experienced | 6 | SAGAT | By Level | 1 | 1 | Level 1 SA sensitive to interface type, scenarios and phase |
| **(Carmody & Gluckman, 1993)** | Process control | Microworld | General | 32 | SAGAT | By Level | 1 | 1 | Sensitive to automation differences |
| **(Catherwood, Edgar, Sallis, Medley, & Brookes, 2012)** | Other | Microworld | Experienced | 50 | QUASA | QUASA | 0 | 0 | Not sensitive to decision differences |
| **(Catherwood, et al., 2012)** | Other | Live Exercises | Experienced | 16 | QUASA | QUASA | 0 | 0 | Not sensitive to decision differences |
| **(Chancey & Bliss, 2012)** | Military | Microworld | Students | 36 | SAGAT | By Level | 0 | 1 | Not sensitive to information reliability descriptions |
| **(Chandrasekaran, 2019)** | Driving | Simulation | Novice & Experienced | 80 | SAGAT | By Level | 1 | 1 | Sensitive to passenger experience level and conversation modulation |
| **(Chang, Scott, & Hancock, 2014)** | Medical | Microworld | Experienced | 36 | SAGAT | Combined | 1 | 0 | Sensitive to control placement and display conditions |
| **(Chang et al., 2015)** | Medical | Live Exercises | Novice | 10 | SAGAT | By Level | 0.5 | 1 | Marginally sensitive to training condition |
| **(Clark, McLaughlin, & Feng, 2017)** | Driving | Video | Experienced | 50 | SAGAT | Combined | 1 | 0 | Sensitive to automation takeover performance |
| **(Clark, et al., 2017)** | Driving | Video | General | 32 | SAGAT | Combined | 1 | 0 | Sensitive of automation take-over performance |
| **(Cooper et al., 2010)** | Medical | Live Exercises | Novice | 51 | SAGAT | Combined | 0 | 0 | Not sensitive to scenario differences |
| **(Cooper et al., 2012)** | Medical | Live Exercises | Novice | 35 | End of trial queries | Combined | 1 | 0 | Sensitive to scenario differences |
| **(Crooks, Hu, & Mahan, 2001)** | Military | Microworld | Students | 165 | SAGAT | By Query | 1 | 1 | Sensitive to cue type differences |
| **(Crundall, 2016)** | Driving | Video | Novice & Experienced | 30 | SAGAT | By Query | 1 | 0 | Sensitive to experience levels and video clip length |
| **(Crundall, 2016)** | Driving | Video | Novice & Experienced | 42 | SAGAT | By Query | 1 | 0 | Sensitive to experience levels and video clip endpoint |
| **(Crundall, 2016)** | Driving | Video | Novice & Experienced | 30 | SAGAT | By Query | 1 | 0 | Sensitive to experience levels and event type |
| **(Crundall, 2018)** | Driving | Video | Novice & Experienced | 84 | SAGAT | By Query | 1 | 0 | Sensitive to experience levels |
| **(Cummings & Guerlain, 2007)** | Military | Simulation | Experienced | 42 | End of trial queries | ? | 0 | 0 | Not sensitive |
| **(D’Aniello, Gaeta, Gaeta, & Tomasiello, 2018)** | Other | Simulation | Students | 10 | SAGAT | By Query | 1 | 1 | Sensitive to display conditions |
| **(Endsley, 1988)** | Aviation | Simulation | Experienced | 10 | SAGAT | By Query | 1 | 1 | Sensitive to differences in avionics hardware |
| **(Endsley, 1995)** | Aviation | Simulation | Experienced | 6 | SAGAT | By Query | 1 | 1 | Sensitive to display differences |
| **(Endsley & Bolstad, 1994)** | Aviation | Simulation | Experienced | 21 | SAGAT | By Query | 1 | 1 | Sensitive to individual differences |
| **(Endsley & Kaber, 1999)** | Experi-mental | Microworld | Students | 30 | SAGAT | By Level | 1 | 1 | Sensitive to automation differences |
| **(Endsley & Kiris, 1995)** | Driving | Microworld | Experienced | 80 | SAGAT | By Query | 1 | 1 | Sensitive to automation conditions |
| **(Endsley & Rodgers, 1998)** | ATC | Video | Experienced | 40 | SAGAT | By Query | 1 | 1 | Sensitive to task load |
| **(Endsley & Selcon, 1997) also (Endsley, Selcon, Hardiman, & Croft, 1998)** | Aviation | Simulation | Experienced | 12 | SAGAT | By Query | 0.5 | 1 | Moderately sensitive to display conditions |
| **(Endsley, Mogford, & Stein, 1997)** | ATC | Simulation | Experienced | 10 | SAGAT | By Query | 1 | 1 | Sensitive to free flight conditions |
| **(Endsley, Sollenberger, & Stein, 1999) also (Jones & Endsley, 2004)** | ATC | Simulation | Experienced | 10 | SAGAT | By Query | 1 | 1 | Sensitive to display differences |
| **(Falkland & Wiggins, 2019)** | ATC | Microworld | Students | 68 | SAGAT | By Level | 1 | 1 | Sensitive to individual differences in cue utilization |
| **(Franz et al., 2015)** | Driving | Simulation | Experienced | 45 | SAGAT | By Query | 1 | 1 | Sensitive to automation conditions |
| **(Giacobe, 2013)** | Other | Microworld | Novice | 28 | SAGAT | Combined | 0 | 0 | Not sensitive to display conditions |
| **(Golightly, Balfe, Sharples, & Lowe, 2009)** | Other | Simulation | Experienced | 6 | End of trial queries | Combined | 0 | 0 | Not sensitive to automation conditions |
| **(Gombolay, Bair, Huang, & Shah, 2017)** | Robotics | Simulation | Students | 20 | End of trial queries | By Query | 1 | 0 | Sensitive to automation conditions |
| **(González-Giraldo et al., 2018)** | Experimental | Experimental | Students | 230 | SAGAT | By Level | 1 | 1 | Sensitive to genetic difference in subjects |
| **(Gronlund, Ohrt, Dougherty, Perry, & Manning, 1998)** | ATC | Simulation | Experienced | 11 | SAGAT | By Query | 1 | 1 | Sensitive to aircraft importance |
| **(Guarino, Harper, Roth, Liu, & Vincenzi, 2009)** | Aviation | Simulation | Novice | 36 | End of trial queries | Combined | 0 | 0 | Not sensitive to display condition |
| **(Gugerty, 1998)** | Driving | Simulation | Experienced | 26 | SAGAT | By Query | 1 | 1 | Sensitive to vehicle locations |
| **(Hallbert, 1997)** | Process control | Simulation | Experienced | 8 | SACRI | SACRI | 1 | 0 | Sensitive to scenario differences and timeline |
| **(Hänsel et al., 2012)** | Medical | Simulation | Novice | 59 | SAGAT | Combined | 1 | 0 | Sensitive to training differences |
| **(Hauss & Eyferth, 2003)** | ATC | Simulation | Experienced | 11 | SALSA | SALSA | 1 | 0 | Sensitive to planning concept |
| **(Heenan, Herdman, Brown, & Robert, 2014)** | Driving | Simulation | Experienced | 28 | End of trial queries | By Query | 1 | 0 | Sensitive to vehicle position and conversation condition |
| **(Hoang, Jung, Holbrook, & Malik, 2011)** | ATC | Simulation | Experienced | 2 | SAGAT | Combined | 1 | 0 | Sensitive to advisories at high workload but not low workload |
| **(Hogan, Pace, Hapgood, & Boone, 2006)** | Medical | Simulation | Novice & Experienced | 16 | SAGAT | Combined | 1 | 0 | SAGAT correlated with expertise and performance scores |
| **(Hogg, Torralba, & Volden, 1993)** | Process control | Simulation | Experienced | 11 | SACRI | SACRI | 1 | 0 | Sensitive to expertise differences, interface differences, and process disturbances |
| **(Hogg, Folles⊘, Strand-Volden, & Torralba, 1995)** | Process control | Simulation | Novice & Experienced | 8 | SACRI | SACRI | 1 | 0 | Sensitive to scenario and subject differences |
| **(Hong, Andrew, & Kenny, 2015)** | Other | Simulation | General | 12 | SAGAT | Combined | 1 | 0 | Sensitive to augmented reality conditions |
| **(Hou, Kobierski, & Brown, 2007)** | Robotics | Simulation | Experienced | 24 | SAGAT | Combined | 1 | 0 | Sensitive to adaptive interface conditions |
| **(Hudson, Taylor, Kozachik, Shaefer, & Wilson, 2015)** | Medical | Simulation | Experienced | 12 | SAGAT | Combined | 1 | 1 | Sensitive to individual differences |
| **(Ikuma, Harvey, Taylor, & Handal, 2014)** | Process control | Simulation | Students | 10 | SAGAT | By Level | 1 | 1 | Sensitive to display and workload interactions |
| **(Jang, 2013)** | Process control | Simulation | Experienced | 8 | SACRI | SACRI | 0 | 0 | Not sensitive to display condition |
| **(Jannat, 2018)** | Driving | Simulation | Experienced | 67 | SAGAT | By Level | 1 | 1 | Sensitive to presence of cyclist |
| **(Jeon, Walker, & Gable, 2014)** | Driving | Simulation | Experienced | 35 | End of trial queries | Combined | 0.5 | 0 | Marginal sensitivity to anger |
| **(Jipp & Ackerman, 2016)** | ATC | Simulation | Students | 57 | SAGAT | By Level | 1 | 1 | Sensitive to automation |
| **(Johannsdottir & Herdman, 2010)** | Driving | Simulation | Experienced | 18 | End of trial queries | By Query | 1 | 0 | Sensitive to vehicle position and secondary tasking |
| **(Johannsdottir & Herdman, 2010)** | Driving | Simulation | Experienced | 24 | End of trial queries | By Query | 1 | 0 | Sensitive to vehicle position and secondary tasking |
| **(Jones & Endsley, 2004) also (Jones & Endsley, 2000)** | Military | Simulation | Experienced | 20 | SAGAT | By Query | 1 | 1 | Sensitive to scenario differences |
| **(Jones, Quoetone, Ferree, Magsig, & Bunting, 2003)** | Other | Simulation | Experienced | 28 | SAGAT | By Query | 1 | 1 | Sensitive to experience types |
| **(Joshi, 2018)** | Medical | Simulation | Novice | 46 | SAGAT | Combined | 0 | 0 | Not sensitive to scenario differences |
| **(Kaber & Endsley, 2004)** | Experi-mental | Microworld | Students | 30 | SAGAT | By Level | 1 | 1 | Sensitive to automation conditions |
| **(Kaber, Perry, Segall, McClernon, & Prinzel III, 2006)** | Experi-mental | Microworld | General | 8 | SALSA | SALSA | 1 | 0 | Sensitive to automation conditions |
| **(Kaber, Sangeun, Zahabi, & Pankok, 2016)** | Driving | Simulation | Experienced | 16 | SAGAT | Combined | 1 | 0 | Sensitive to secondary tasking and hazardous event exposure |
| **(Kaber, Onal, & Endsley, 2000)** | Other | Simulation | Students | 10 | SAGAT | By Level | 1 | 1 | Sensitive to automation conditions |
| **(Kaber, Wright, & Sheik-Nainar, 2006)** | Other | Microworld | Students | 32 | SAGAT | Combined | 1 | 0 | Sensitive to automation conditions |
| **(Kass, Cole, & Stanny, 2007)** | Driving | Simulation | Novice & Experienced | 49 | SAGAT | Combined | 1 | 0 | Sensitive to experience level and cell phone usage |
| (**Kass, VanWormer, Mikulas, Legan, & Bumgarner, 2011)** | Driving | Simulation | Experienced | 16 | SAGAT | Combined | 1 | 0 | Sensitive to training condition |
| **(Kim & Kaber, 2009) also (Kim & Kaber, 2014)** | Aviation | Simulation | Experienced | 8 | SAGAT | Combined | 1 | 0 | Sensitive to display conditions |
| **(Koch et al., 2013)** | Medical | Simulation | Experienced | 12 | SAGAT | Combined | 1 | 0 | Sensitive to display conditions |
| **(Lancaster & Casali, 2008)** | Aviation | Simulation | Experienced | 16 | SAGAT | By Query | 1 | 1 | Sensitive to data-link flight conditions |
| **(Lee, Gore, & Campbell, 1999)** | Driving | Simulation | Experienced | 32 | SAGAT | Combined | 1 | 0 | Sensitive to information availability and age |
| **(Leggatt, 2004)** | Military | Simulation | Experienced | 105 | QUASA | QUASA | 1 | 0 | Sensitive to differences in sites, and functional groups |
| **(Li, Sanderson, Memisevic, & Wong, 2007)** | Process control | Simulation | Experienced | 6 | End of trial queries | By Level | 1 | 0 | Sensitive to display conditions |
| **(Liang, 2010)** | Other | Live Exercises | Experienced | 49 | End of trial queries | Combined | 1 | 0 | Sensitive to display conditions |
| **(Lichacz, Cain, & Patel, 2003)** | ATC | Simulation | General | 32 | SAGAT | By Query | 1 | 1 | Sensitive to perceptual and temporal demand |
| **(Lin, 2010)** | Process control | Simulation | Students | 20 | SAGAT | By Query | 1 | 1 | Sensitive to automation conditions |
| **(Lin et al., 2012)** | Aviation | Simulation | Experienced | 8 | SAGAT | By Level | 1 | 0 | Sensitive to datalink type by phase of flight interactions |
| **(Luz et al., 2014)** | Medical | Simulation | Experienced | 7 | SAGAT | By Query | 0 | 1 | Not sensitive |
| **(Ma & Kaber, 2005)** | Driving | Simulation | Experienced | 18 | End of trial queries | By Level | 1 | 0 | Sensitive to automation and cell phone use |
| **(Ma & Kaber, 2007)** | Driving | Simulation | Experienced | 20 | SAGAT | By Level | 1 | 1 | Sensitive to navigational aid |
| **(Manzey et al., 2011)** | Medical | Simulation | Novice | 14 | SAGAT | By Query | 1 | 1 | Sensitive to automated navigation support (SA of anatomy) |
| **(McClernon, Kaber, Perry, & Segall, 2006)** | Experimental | Microworld | General | 8 | SAGAT | By Level | 1 | 1 | Sensitive to automation mode (L3 SA); L1, L2, overall combined scores not sensitive |
| **(McGeorge et al., 2015)** | Medical | Simulation | Experienced | 32 | SAGAT | By Query | 0 | 1 | Not sensitive to display conditions |
| **(Metzger & Parasuraman, 2001)** | ATC | Simulation | Experienced | 18 | End of trial queries | By Query | 1 | 0 | Marginal sensitivity to automation |
| **(Motz et al., 2009)** | Other | Simulation | Experienced | 26 | SAGAT | By Level | 1 | 1 | Sensitive to display design |
| **(Müller, Manzey, Schreiter, & Luckner, 2015)** | Aviation | Simulation | Experienced | 7 | End of trial queries | Combined | 0 | 0 | Not sensitive to display conditions |
| **(Naderpour, Lu, & Zhang, 2016)** | Process control | Simulation | Experienced | 10 | SAGAT | Combined | 1 | 0 | Sensitive to display design |
| **(Nunes, 2003)** | ATC | Simulation | Novice | 20 | SAGAT | By Query | 0.5 | 1 | Sensitive to workload, not to display differences |
| **(Oberheid, Weber, & Rudolph, 2009)** | ATC | Microworld | Novice | 10 | SAGAT | Combined | 1 | 0 | Sensitive to display type |
| **(O'Meara et al., 2015)** | Medical | Live Exercises | Novice | 39 | End of trial queries | Combined | 1 | 0 | Improvement in SA over 3 scenarios; sensitive to between group differences |
| **(Parush, Hazan, & Shtekelmacher, 2017)** | Other | Microworld | General | 42 | SAGAT | By Level | 1 | 1 | Sensitive to individual vs team conditions |
| **(Parush & Rustanjaja, 2013)** | Other | Microworld | General | 42 | SAGAT | Combined | 1 | 0 | Sensitive to information completeness |
| **(Parush, 2017)** | Medical | Simulation | Experienced | 13 | SAGAT | By level | 1 | 1 | Sensitive to display conditions |
| **(Pennathur, 2011)** | Medical | Simulation | Experienced | 17 | SAGAT | Combined | 1 | 0 | Sensitive to experience type |
| **(Perry, Sheik-Nainar, Segall, Ma, & Kaber, 2008)** | Military | Simulation | Students | 16 | SAGAT | By Level | 1 | 1 | Sensitive to physical workload |
| **(Puuska, 2018)** | Other | Simulation | Novice | 13 | SAGAT | By level | 0 | 1 | Not sensitive |
| **(Price, Tenan, Head, Maslin, & LaFiandra, 2016)** | Military | Simulation | General | 21 | QUASA | QUASA | 1 | 0 | Sensitive to stress manipulation |
| **(Radlmayr, Brüch, Schmidt, Solbeck, & Wehner, 2018)** | Driving | Simulation | Experienced | 57 | SAGAT | Combined | 1 | 0 | Sensitive to automation monitoring conditions |
| **(Randel, Pugh, & Reed, 1996)** | Military | Simulation | Novice & Experienced | 28 | SAGAT | By Query | 1 | 1 | Sensitive to experience level and emitter type |
| **(Riley & Kaber, 2001) also (Riley, Kaber, & Draper, 2004)** | Robotics | Simulation | Students | 24 | SAGAT | Combined | 0.5 | 0 | Moderately sensitive to level of difficulty manipulations |
| **(Riley & Strater, 2006)** | Robotics | Simulation | Students | 20 | SAGAT | By Query | 1 | 1 | Sensitive to control mode |
| **(Riley et al., 2008)** | Robotics | Simulation | Students | 24 | SAGAT | By Query | 1 | 1 | Sensitive to control mode |
| **(Riley, Scielzo, Hyatt, Davis, & Colombo, 2009)** | Robotics | Simulation | Students | 24 | SAGAT | Combined | 1 | 0 | Sensitive to control mode and communications differences |
| **(Rose, Bearman, & Dorrian, 2018)** | Other | Simulation | Experienced & Students | 49 | SAGAT | Combined | 1 | 0 | Sensitive to experience by trial interaction |
| **(Ross, Barnett, & Meliza, 2007)** | Military | Simulation | Experienced & Students | 26 | SAGAT | Combined | 1 | 0 | Sensitive to task difficulty |
| **(Schaffer, 2018)** | Other | Microworld | General | 901 | SAGAT | By Level | 1 | 1 | Sensitive to display conditions |
| **(Selkowitz, Lakhmani, Chen, & Boyce, 2015)** | Military | Microworld | General | 45 | SAGAT | By Query | 1 | 1 | Sensitive to transparency conditions |
| **(Selkowitz, Lakhmani, Larios, & Chen, 2016) also (Selkowitz, 2017)** | Robotics | Microworld | General | 60 | SAGAT | By Level | 1 | 1 | Sensitive to display conditions |
| **(Sethumadhavan, 2009)** | ATC | Microworld | General | 72 | SAGAT | Combined | 1 | 0 | Sensitive to automation conditions |
| **(Sethumadhavan, 2011)** | ATC | Microworld | Students | 72 | SAGAT | Combined | 1 | 0 | Sensitive to level of automation conditions and automation failures |
| **(Silva, Grigoleit, Ann Burress, & Fitzpatrick, 2017)** | Process control | Simulation | Experienced | 11 | SAGAT | Combined | 0 | 0 | Not sensitive to experience level |
| **(Smets, te Brake, Lindenberg, & Neerincx, 2007)** | Other | Microworld | Students | 20 | SAGAT | By Query | 1 | 1 | Sensitive to display conditions |
| **(Snow & Reising, 1999)** | Aviation | Simulation | Experienced | 12 | SAGAT | By Query | 1 | 0 | Sensitive to display conditions |
| **(Snow & French, 2002)** | Aviation | Simulation | Experienced | 13 | SAGAT | Combined | 1 | 0 | Sensitive to visibility differences; not sensitive to display differences |
| **(Soliman & Mathna, 2009)** | Driving | Simulation | Novice & Experienced | 56 | SAGAT | Combined | 1 | 0 | Sensitive to experience level and training |
| **(Soliman, 2010)** | Driving | Simulation | Experienced | 40 | SAGAT | Combined | 1 | 0 | Sensitive to scenario difficulty and individual differences in executive function |
| **(Strater, Endsley, Pleban, & Matthews, 2001)** | Military | Simulation | Novice & Experienced | 14 | SAGAT | By Query | 1 | 1 | Sensitive to experience levels and scenarios |
| **(Strater et al., 2004)** | Military | Live Exercises | Novice | 50 | SAGAT | By Query | 1 | 1 | Sensitive to training conditions |
| **(Strater, Faulkner, Hyatt, & Endsley, 2006)** | Military | Simulation | Students | 16 | SAGAT | By Level | 1 | 1 | Sensitive to display type |
| **(Strater et al., 2010)** | Military | Simulation | Experienced | 60 | SAGAT | By Level | 1 | 1 | Sensitive to changes over time |
| **(Stratton, Furey, & Hogan, 2014)** | Medical | Simulation | Novice | 9 | SAGAT | Combined | 0 | 0 | Not sensitive to fatigue levels |
| **(Taylor, 2016)** | Driving | Live exercises | Experienced | 62 | End of trial queries | By Level | 1 | 0 | Sensitive to individual differences |
| **(Tharanathan, Laberge, Bullemer, Reising, & McLain, 2010)** | Process control | Simulation | Experienced | 18 | SAGAT | By Level | 1 | 1 | Sensitive to display type and scenario complexity |
| **(Tharanathan, Bullemer, Laberge, Reising, & Mclain, 2012)** | Process control | Microworld | Experienced | 18 | SAGAT | By Level | 1 | 1 | Sensitive to display conditions and scenario type |
| **(Tremblay, Vachon, Rousseau, & Breton, 2012)** | Military | Simulation | Students | 43 | QUASA | QUASA | 1 | 0 | Sensitive to display differences |
| **(Trujillo, 2004)** | Aviation | Simulation | Experienced | 12 | End of trial queries | Combined | 1 | 0 | Sensitive to event type |
| **(Tumkaya et al., 2013)** | Experi-mental | Microworld | Experienced | 84 | SAGAT | Combined | 1 | 0 | Sensitive to clinical conditions between participants |
| **(Vachon, Lafond, Vallieres, Rousseau, & Tremblay, 2011)** | Military | Microworld | General | 63 | QUASA | QUASA | 1 | 0 | Sensitive to display differences |
| **(Van den Beukel, 2016)** | Driving | Simulation | Experienced | 37 | SAGAT | By level | 1 | 1 | Sensitive to display differences |
| **(Van den Beukel, 2017)** | Driving | Simulation | Experienced | 24 | SAGAT | By level | 1 | 1 | Sensitive to display differences |
| **(Ventsislavova, 2016)** | Driving | Video | Novice & Experienced | 143 | SAGAT | By level | 1 | 0 | Sensitive to experience levels and type |
| **(Ventsislavova, 2019)** | Driving | Video | Novice & Experienced | 153 | SAGAT | By level | 1 | 0 | Sensitive to experience levels |
| **(Walker, Stanton, & Young, 2008) also (Walker, Stanton, & Young, 2006)** | Driving | Simulation | Experienced | 35 | SAGAT | d’ sensitivity and confi-dence level | 1 | 0 | Sensitive to feedback conditions |
| **(Weber, Oberheid, & Papenfuss, 2013)** | ATC | Microworld | Students | 78 | SAGAT | By Level | 1 | 1 | Sensitive to visual aiding condition |
| **(Wei, Zhuang, Wanyan, & Wang, 2013)** | Aviation | Simulation | Students | 30 | SAGAT | Combined | 1 | 0 | Sensitive to display type |
| **(Weiler, 2018)** | Medical | Simulation | Students | 69 | End of trial queries | Combined | 0 | 0 | Not sensitive to role assignment |
| **(Willems & Heiney, 2001)** | ATC | Simulation | Experienced | 16 | End of trial queries | By Query | 1 | 0 | Sensitive to automation conditions |
| **(Willems & Heiney, 2001)** | ATC | Simulation | Experienced | 16 | SAVANT | SAVANT | 0.5 | 0 | Partially sensitive to automation conditions |
| **(Wolf, 2018)** | Other | Live Exercises | General | 27 | SAGAT | By level | 1 | 1 | Sensitive to exertion conditions |
| **(Wright, Kaber, & Endsley, 2003)** | Aviation | Simulation | Novice & Experienced | 16 | SAGAT | By Level | 1 | 1 | Sensitive to scenario manipulation, marginally sensitive to automation conditions |
| **(Wright, 2015)** | Aviation | Simulation | Students | 62 | SAGAT | By level | 0 | 1 | Not sensitive to display conditions |
| **(Wu, 2016)** | Process Control | Simulation | Students | 48 | SAGAT | Combined | 1 | 0 | Sensitive to display conditions and alarm frequency |
| **(Wulf, Zeeb, Rimini-Doring, Arnon, & Gauterin, 2013)** | Driving | Simulation | Experienced | 90 | SAGAT | Combined | 1 | 0 | Sensitive to display differences and secondary tasks |
| **(Zhang et al., 2002)** | Medical | Simulation | Experienced & Students | 24 | SAGAT | By Level | 1 | 1 | Sensitive to display type |
| **(Zhang, Kaber, & Hsiang, 2010)** | Other | Simulation | Students | 12 | SAGAT | By Level | 1 | 1 | Sensitive to mental model differences |

# Appendix B: SPAM Sensitivity Studies

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **(Alexander & Wickens, 2005)** | Aviation | Simulation | Experienced | 24 | SPAM | 1 | Sensitive to display differences |
| **(Burns, et al., 2008)** | Process Control | Simulation | Experienced | 6 | Real time probes | 1 | Imbedded probes (L2 and L3) sensitive to interface type, scenarios and phase and interaction |
| **(Chen, Loft, Huf, Braithwaite, & Visser, 2014)** | Submarine Manage-ment | Microworld | Students | 38 | SPAM | 0 | Not sensitive to automation condition |
| **(Cummings & Guerlain, 2007)** | Military | Simulation | Experienced | 42 | Real time probes | 1 | Sensitive to session and number of missiles |
| **(Dao et al., 2009)** | Aviation | Simulation | Experienced | 17 | Real time probes | 1 | Sensitive to automation condition |
| **(Dao et al., 2011)** | Aviation | Simulation | Experienced | 8 | SPAM | 1 | Sensitive to automation condition |
| **(Dattel et al., 2011)** | Driving | Videos | Students | 34 | Real time probes | 1 | Speed of answering irrelevant questions sensitive to inattentional blindness |
| **(Dattel et al., 2012)** | Driving | Videos | Students | 82 | Real time probes | 1 | RT sensitive to working memory differences on irrelevant questions, but not relevant questions |
| **(Dattel et al., 2013)** | Aviation | Simulation | Experienced | 20 | Real time probes | 1 | Accuracy and RT sensitive to training conditions |
| **(Dattel, Battle, Stefonetti, Bifano, & Majdic, 2015)** | Driving | Videos | Students | 27 | Real time probes | 1 | RT sensitive to differences in inattentional insensitivity |
| **(Dattel et al., 2018)** | Driving | Videos | Students | 33 | Real time probes | 1 | Accuracy sensitive to differences in inattentional insensitivity |
| **(Edwards, 2016)** | ATC | Simulation | Experienced | 8 | SPAM | 1 | RT sensitive to automation conditions |
| **(Endsley, 2017)** | Driving | Live exercise | Experienced | 1 | Real time probes | 0 | Not sensitive to automation differences (accuracy only) |
| **(Hanratty et al., 2009)** | Military | Simulation | Students | 32 | Real time probes | 0 | Not sensitive to display type |
| **(Jones & Endsley, 2004) also (Endsley, Sollenberger, Nakata, Hough, & Stein, 1999)** | ATC | Simulation | Experienced | 10 | Real time probes | 0 | Real time probes not sensitive to display conditions |
| **(Jones & Endsley, 2004)** | Military | Simulation | Experienced | 20 | Real time probes | 1 | Real time probe accuracy and RT sensitive across scenarios |
| **(Kaber, Riley, Sheik-Nainar, Hyatt, & Reynolds, 2006) also (Kaber et al., 2013)** | Military | Simulation | Experienced | 27 | Real time probes | 0 | Not sensitive to scenario or team |
| **(Kaber, Zhang, Jin, Mosaly, & Garner, 2012)** | Driving | Simulation | Experienced | 20 | Real time probes | 1 | Accuracy sensitive to differences in age and hazard events |
| **(Koch, et al., 2013)** | Medical | Live exercise | Experienced | 8 | Real time probes | 1 | Sensitive to display differences |
| **(Loft et al., 2016)** | Submarine Manage-ment | Microworld | Students | 50 | SPAM | 1 | Sensitive to effects of uncertainty and performance |
| **(Loft, et al., 2016)** | Submarine Manage-ment | Simulation | Experienced | 16 | SPAM | 0 | Not sensitive to uncertainty and not significantly predictive of performance |
| **(Noah, 2017)** | Process Control | Simulation | Students | 20 | SPAM | 0 | No sensitive to display differences |
| **(Schuster, Keebler, Jentsch, & Zuniga, 2012)** | Robotics | Microworld | Students | 53 | SPAM | 1 | Sensitive to differences in mission but not information condition |
| **(Silva, et al., 2017)** | Process Control | Simulation | Experienced | 11 | SPAM | 1 | Less experienced had better accuracy |
| **(Strybel, Vu, Battiste, & Johnson, 2013) also (Strybel et al., 2010)** | Aviation | Simulation | Experienced | 8 | SPAM | 1 | Sensitive to operational concept |
| **(Strybel et al., 2016)** | ATC | Simulation | Students | 24 | SPAM | 0 | Not sensitive to automation condition, traffic density, or reliability |

# Appendix C: Predictiveness of SA Metrics

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Paper** | **Domain** | **Environment** | **Subjects** | **Number** | **Measure** | **Predictive** | **Mean Pearson's R** | **Findings** |
| **(Bacon & Strybel, 2013)** | ATC | Simulation | Novice | 12 | SPAM | 1 | 0.324 | Predictive of performance |
| **(Chauvin, Clostermann, & Hoc, 2008)** | Ship Navigation | Simulation | Novice | 90 | SAGAT | 1 | --- | Predictive of decision differences |
| **(Cooper, et al., 2010)** | Health Care | Live Exercises | Novice | 51 | SAGAT | 0.5 | --- | Moderate correlation with subjective performance rating |
| **(Cummings & Guerlain, 2007)** | Military | Simulation | Experienced | 42 | SPAM | 1 | 0.432 | Predictive of performance |
| **(Durso et al., 1998)** | ATC | Simulation | Experienced | 12 | SPAM | 1 | 0.545 | SPAM provided additional sensitivity |
| **(Durso, et al., 1998)** | ATC | Simulation | Experienced | 12 | SAGAT | 1 | 0.617 | Predictive of performance |
| **(Durso, Bleckley, & Dattel, 2006)** | ATC | Microworld | Students | 88 | SPAM | 1 | 0.344 | SPAM added 9% to prediction of 2 individual performance measures (9% and 15%) over cognitive battery |
| **(Durso, et al., 2006)** | ATC | Microworld | Students | 88 | SAGAT | 0.5 | 0.140 | SAGAT added to prediction of 1 individual performance measure (2%) over cognitive battery (only 1 query/stop) |
| **(Endsley, 1990b)** | Military aviation | Simulation | Experienced | 25 | SAGAT | 1 | --- | SAGAT predictive of performance |
| **(Entin, 2000)** | Helicopter | Simulation | Experienced | 24 | SAGAT | 1 | 0.443 | Predictive of performance in all 3 mission phases |
| **(Gatsoulis, Virk, & Dehghani-Sanij, 2010)** | Robot Control | Simulation | Naive | 32 | SAGAT | 1 | 0.447 | Predictive of performance |
| **(Gugerty, 1997)** | Driving | Simulation | Experienced | 34 | SAGAT | 1 | 0.466 | Predictive of performance |
| **(Gutzwiller & Clegg, 2012)** | Network Fire Chief | Microworld | Students | 119 | End of Trial | 1 | 0.650 | Predictive of performance (L3) |
| **(Hamilton, Mancuso, Mohammed, Tesler, & McNeese, 2017)** | Neocities - Emergency Response | Microworld | Students | 216 | SAGAT | 1 | 0.350 | Predictive of performance |
| **(Hogan, et al., 2006)** | Trauma life support | Simulation | Novice to Experienced | 16 | SAGAT | 1 | 0.806 | Predictive of expertise and performance scores |
| **(Ikuma, et al., 2014)** | Process control | Simulation | Students | 10 | SAGAT | 1 | --- | SA and workload interaction predictive of performance |
| **(Jannat, 2018)** | Driving | Simulation | Experienced | 67 | SAGAT | 1 | 0.3 | Predictive of performance |
| **(Jipp & Ackerman, 2016)** | ATC | Simulation | Students | 57 | SAGAT | 1 | 0.315 | Predictive of performance |
| **(Jones & Endsley, 2004) also (Endsley, Sollenberger, Nakata, & Stein, 2000)** | ATC | Simulation | Experienced | 10 | SAGAT | 1 | 0.301 | Predictive of performance |
| **(Jones & Endsley, 2004) also (Endsley, et al., 2000)** | ATC | Simulation | Experienced | 10 | Real time probes | 0 | 0.000 | Not predictive of performance |
| **(Kaber & Endsley, 2004)** | Multitask | Microworld | Students | 30 | SAGAT | 1 | 0.452 | Predictive of primary task performance |
| **(Kaber, Perry, et al., 2006)** | Multitask | Microworld | General | 8 | SALSA | 0.5 | 0.202 | Weak correlation with performance |
| **(Kaber, et al., 2016)** | Driving | Simulation | Experienced | 16 | SAGAT | 1 | 0.362 | Predictive of performance |
| **(Kass, et al., 2011)** | Driving | Simulation | Experienced | 16 | SAGAT | 1 | 0.650 | Predictive of performance |
| **(Kraemer, 2015)** | ATC | Simulation | Students | 57 | SAGAT | 0 | --- | Not predictive of performance |
| **(Kraemer, 2015)** | ATC | Simulation | Students | 57 | SPAM | 1 | --- | Predictive of performance |
| **(Li, et al., 2007)** | Hydro Power Control Room | Simulation | Experienced | 6 | End of Trial | 1 | --- | Sensitive to display conditions |
| **(Lo, Sehic, Brookhuis, & Meijer, 2016)** | Train Driving | Simulation | Experienced | 22 | SAGAT | 0 | 0.000 | Not predictive of performance |
| **(Loft, Morrell, & Huf, 2013)** | Submarine Management | Microworld | Students | 55 | SPAM | 1 | 0.463 | Moderate correlation with performance |
| **(Loft et al., 2015)** | Submarine | Microworld | Students | 171 | SAGAT | 1 | 0.349 | SAGAT accounted for 2x the variance of SPAM, predicted more performance measures |
| **(Loft, et al., 2016)** | Submarine Management | Microworld | Students | 50 | SPAM | 1 | 0.585 | Predictive of performance |
| **(Loft et al., 2018)** | Submarine Management | Microworld | Students | 59 | SAGAT | 1 | 0.345 | Correlated with Performance |
| **(Ma & Kaber, 2005)** | Driving | Simulation | Experienced | 20 | SAGAT | 1 | 0.605 | Predictive of performance |
| **(McDermott & Fisher, 2013)** | Robot | Microworld | General | 39 | End of Trial | 1 | 0.392 | Sensitive to performance differences |
| **(McGowan & Banbury, 2004)** | Driving Hazard Anticipation | Videos | Experienced | 152 | SAGAT | 1 | 0.557 | Correlated with hazard perception |
| **(McKenna et al., 2014))** | Nursing | Live Exercises | Novice | 97 | End of Trial | 1 | --- | Correlated with performance differences |
| **(O'Brien & O'Hare, 2007)** | ATC | Microworld | Students | 20 | SAGAT | 1 | 0.575 | SAGAT predictive of performance; Combined Score |
| **(Paletta et al., 2017)** | Robot | Simulation | General | 19 | SAGAT | 1 | 0.608 | Predictive of performance |
| **(Pierce, Strybel, & Vu, 2008)** | ATC | Microworld | Students | 21 | SAGAT | 0.5 | 0.391 | Correlated with performance |
| **(Pierce, Strybel, et al., 2008)** | ATC | Microworld | Students | 21 | SPAM | 1 | 0.518 | Correlated with performance |
| **(Prince, Ellis, Brannick, & Salas, 2007)** | Aviation | Simulation | Novice | 41 | SAGAT | 1 | 0.410 | Predictive of performance |
| **(Puuska, 2018)** | Network Monitoring | Simulation | Novice | 13 | SAGAT | 1 | 0.6315 | Predictive of performance with new display |
| **(Salmon et al., 2009)** | Military planning | Microworld | Students | 20 | SAGAT | 1 | --- | SAGAT predictive of performance |
| **(Sethumadhavan, 2011)** | ATC | Microworld | Students | 72 | SAGAT | 1 | 0.488 | Predictive of performance |
| **(Soliman, 2010)** | Driving | Simulation | Experienced | 40 | SAGAT | 1 | --- | Predictive of driving violations |
| **(Stanners & French, 2005)** | Military - Operation Flashpoint | Game | Experienced | 24 | SAGAT | 1 | 0.450 | Predictive of decision making and planning scores |
| **(Strybel, Vu, Kraft, & Minakata, 2008)** | Aviation | Simulation | Experienced | 13 | SPAM | 1 | 0.283 | Predictive of performance . SPAM every 2 minutes |
| **(Strybel, et al., 2008)** | Aviation | Simulation | Experienced | 13 | SAGAT | 0.5 | 0.265 | Predictive of performance . 2 SAGAT/trial, 30 minute trials |
| **(Strybel, Minakata, Nguyen, Pierce, & Vu, 2009)** | ATC | Simulation | Novice and Experienced | 16 | SPAM | 1 | --- | Some queries not answered, presumably due to workload |
| **(Strybel, et al., 2013)** | Aviation | Simulation | Experienced | 8 | SPAM | 1 | 0.323 | SPAM predictive of performance (conflict resolution time) |
| **(Sulistayawati, Wickens, & Chui, 2011)** | Military Aviation | Game | Experienced | 16 | SAGAT | 1 | 0.690 | SA and overconfidence predicted 57% of variance in performance |
| **(Zhang, et al., 2010)** | Security patrol | Simulation | Students | 12 | SAGAT | 1 | 0.407 | SAGAT predictive of performance |

# Appendix D: Intrusiveness of SA Metrics

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Study** | **Domain** | **Environment** | **Subjects** | **SAGAT** | **SPAM** | **Notes** |
| **(Durso, et al., 1998)** | ATC | Microworld | Students | No effect on performance | No effect on performance | Only 1 SAGAT question/stop |
| **(Durso, et al., 2006)** | ATC | Microworld | Students | No effect on performance or workload | No effect on performance or workload | Only 1 SAGAT question/stop |
| **(Bacon & Strybel, 2013)** | ATC | Simulation | Novice | ---- | No effect on performance or workload | Trend towards faster RT on conflicts of probed aircraft |
| **(Endsley, 1995)** | Aviation | Simulation | Experienced | No effect on performance | --- | 0, 1, 2 or 3 stops of 30, 60 or 120 seconds |
| **(Endsley, 2000)** | Aviation | Simulation | Experienced | No effect on performance | --- | Performance not effected by SAGAT stop or by possibility of SAGAT stop |
| **(Hogg, et al., 1995)** | Nuclear Power | Simulation | Experienced | No effect on performance | --- | (SACRI) Subjective performance |
| **(Keeler et al., 2015)** | ATC | Simulation | Novice |  | No effect on performance | Computer version of SPAM |
| (Kraemer, 2015) | ATC | Simulation | Students | Improved performance | No effect on performance | Confounded with order effect (learning) |
| **(Loft, et al., 2015)** | Submarine | Microworld | Students | Small effect on workload | No effect on performance or workload | More queries with SAGAT (2% increase in workload) |
| **(Loft, et al., 2016)** | Submarine | Microworld | Experienced & Students | --- | Negative effect on performance | Experts took almost 20 seconds to accept SPAM queries – longer when SA lower and uncertainty higher |
| **(Morgan, Chiappe, Kraut, Strybel, & Vu, 2012)** | ATC | Microworld | Novices | No effect on workload | No effect on workload |  |
| **(Pierce, 2012)** | ATC | Microworld | Students | --- | Negative effect on performance & workload |  |
| **(Pierce, Vu, Nguyen, & Strybel, 2008)** | ATC | Microworld | Students | --- | Negative effect on performance |  |
| **(Pierce, Strybel, et al., 2008)** | ATC | Microworld | Students | No effect on performance | Negative effect on performance | SAGAT end of trial |
| **(Shelton, Kinston, Molyneux, & Ambrose, 2013)** | Health Care | Simulation | Novice | --- | Negative effect on discussion | Verbal queries viewed as intrusive, confused with dialog |
| **(Silva et al., 2013)** | ATC | Simulation | Novice | --- | No effect on performance | Computer version of SPAM |
| **(Snow & Reising, 1999)** | Aviation | Simulation | Experienced | No effect on performance | No effect on performance |  |
| **(Strybel, et al., 2008)** | Aviation | Simulation | Experienced | No effect on performance | Negative effect on performance | Performance worse on SPAM trials compared to SAGAT trials |

# Appendix E. Other Papers Relevant to Methodology

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Paper** | **Domain** | **Environment** | **Subjects** | **Number** | **Measure** | **Topic** | **Findings** |
| **(Durso, et al., 2006)** | ATC | Microworld | Students | 88 | SAGAT | Memory | SAGAT correlated with complex working memory (operational word span and reading span) and fluid intelligence (only 1 query/stop). Measures of short term memory and visual memory were not correlated with SAGAT |
| **(Cak, Say, & Misirlisoy, 2019)** | Aviation | Simulation | Experienced | 36 | SAGAT; SPAM | Memory | Both SAGAT and SPAM correlated with Operation Span measure of complex working memory |
| **(Endsley, 1990a) also (Endsley, 1995)** | Military aviation | Simulation | Experienced | 10 | SAGAT | Memory | SA information available from LTM for at least 5-6 minutes after SAGAT freeze without memory decay |
| **(Endsley & Bolstad, 1994)** | Military aviation | Simulation | Experienced | 21 | SAGAT | Memory | Working memory test (immediate/delayed memory) not correlated with SAGAT |
| **(Gonzalez & Wimisberg, 2007)** | Water Purification Plant | Microworld | General | 36 | SAGAT | Memory | Task initially required visual working memory (visual span), but declined over time |
| **(Gonzalez & Wimisberg, 2007)** | Water Purification Plant | Microworld | General | 36 | SA queries (with information showing) | Memory | Did not require visual working memory (visual span); relied on looking on the screen; did not improve with practice |
| **(Gutzwiller & Clegg, 2012)** | Fire control | Microworld | Students | 118 | SAGAT (End of trial) | Memory | No relationship between complex working memory (arrow, symmetry and reading span) and Level 1 SA, positive relationship with Level 3 SA |
| **(Jipp & Ackerman, 2016)** | ATC | Simulation | Students | 57 | SAGAT | Memory | Primary working memory (dot span and figural task switching) not correlated with SAGAT |
| **(Kass, et al., 2007)** | Driving | Simulation | Novice and Experienced | 49 | SAGAT | Memory | Experienced participants had higher SAGAT scores than inexperienced participants |
| **(Strater, et al., 2001)** | Military | Simulation | Novice and Experienced | 14 | SAGAT | Memory | Experienced participants had higher SAGAT scores than inexperienced participants, and paid attention to different things |
| **(Sulistayawati, et al., 2011)** | Military Aviation | Microworld | Experienced | 16 | SAGAT | Memory | Primary working memory (visual span number, auditory letter span, building memory) not correlated with SAGAT |
| **(Alexander & Wickens, 2004)** | Aviation | Static images | Experienced | 12 | Display blanked vs Display present | Speed Accuracy Trade-off | Speed accuracy tradeoffs for memory based response vs when info is present |
| **(Alexander & Wickens, 2005)** | Aviation | Simulation | Experienced | 24 | SAGAT/SPAM | Speed Accuracy Trade-off | Response time 2 seconds faster with SAGAT than SPAM, but less accurate (speed accuracy tradeoff) |
| **(Jones & Endsley, 2004)** | Military air defense | Simulation | Experienced | 20 | SAGAT/SPAM | Speed Accuracy Trade-off | SPAM produces speed-accuracy tradeoff - faster responses with lower accuracy (p=.07) |
| **(Morgan, et al., 2012)** | ATC | Microworld | Novice | 14 | SAGAT/SPAM | Speed Accuracy Trade-off | Information visibility (SPAM) results in speed-accuracy tradeoff compared to when blanked (SAGAT) |
| **(Taber, 2013)** | Emergency Response | Simulaiton | General | 23 | SAGAT/SPAM | Speed Accuracy Trade-off | Slower to respond to SPAM compared to SAGAT due to visually confirming responses |
| **(Cunningham, 2015)** | Aviation | Simulation | Experienced | 35 | SPAM | Workload | Did not respond to ready prompt 16% of the time (due to workload) and did not respond to probe 2.8% |
| **(Durso, et al., 1998)** | ATC | Simulation | Experienced | 12 | SPAM | Workload | Subjects delay answering probes as long at 10 seconds |
| **(Jones & Endsley, 2004)** | ATC | Simulation | Experienced | 10 | Real time probes | Workload | Weak correlation with workload |
| **(Loft, et al., 2016)** | Submarine Management | Microworld | Students | 50 | SPAM | Workload | Participants took as along as 20 seconds to accept queries, taking longer when SA was low or uncertainty was high |
| **(Pierce, 2012)** | ATC | Microworld | Students | 21 | SPAM | Workload | Higher workload with SPAM |
| **(Shelton, et al., 2013)** | Medical Care | Simulation | Novice | 18 | SPAM | Workload | Verbal queries intrusive, confused with dialog; adopted PDA implementation |
| **(Strybel, et al., 2010)** | Aviation | Simulation | Experienced | 8 | SPAM | Workload | SPAM latency measure correlated with workload |
| **(Strybel, et al., 2008)** | Aviation | Simulation | Experienced | 13 | SPAM | Workload | SPAM latency measure correlated with workload |
| **(Strybel, et al., 2016)** | ATC | Microworld | Students | 24 | SPAM with graphics | Workload | Lower % correct with graphical display of aircraft that questions referred to. Higher probability of being correct due to guessing with traditional SPAM |
| **(Strybel, et al., 2013)** | Aviation | Simulation | Experienced | 8 | SPAM | Workload | Did not respond to 5% of probes |
| **(Trapsilawati, Wickens, Qu, & Chen, 2016)** | ATC | Simulation | Students | 24 | SPAM | Workload | Mean latencies in accepting a SPAM probe of between 9 and 23 seconds |
| **(Lau, Jamieson, & Skraaning Jr, 2014)** | Process control | Simulation | Experienced | 3 | SAGAT | Method | Low inter-rater reliability on queries |
| **(Endsley & Bolstad, 1994)** | Military aviation | Simulation | Experienced | 21 | SAGAT | Method | Highly stable (test-retest .99, .98. .92, .98) |
| **(Jackson, Chapman, & Crundall, 2009)** | Driving | Videos | Novice and Experienced | 79 | Hazard perception | Method | Novices did worse than experienced when the screen was blanked |
| **(McGowan & Banbury, 2004)** | Driving Hazard Anticipation | Videos | Experienced | 152 | SAGAT (by query) | Method | Interruptions with relevant or cueing questions improved hazard detection time, but irrelevant questions negatively affected performance. Passive viewing of 20-25 second videos with 10 second interruptions; non-interrupted trials also improved hazard perception time even more |
| **(Gartenberg, Breslow, McCurry, & Trafton, 2014)** | UAV | Microworld | Students | 27 | SAGAT & interruptions of unrelated tasks | Method | SA comprehension was negatively effected by interruptions of unrelated tasks |

# Appendix F. Studies Investigating Team and Shared SA using Direct Objective SA Measures

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Paper** | **Domain** | **Environment** | **Subjects** | **Number** | **Measure** | **Team SA Measure** | **Finding** |
| **(Artman, 1999)** | Emergency response | Microworld | Students | 60 | SAGAT | Shared SA (similarity) | Negative effect of information overload on teams getting information in parallel compared to in serial; more successful teams crosscheck with each other; Planning important to performance |
| **(Bolstad & Endsley, 2003)** | Military | Simulation | Experienced | 25 | SAGAT | Combined Team SA Score; Shared SA (similarity) | Significant differences in Team SA between teams; Significant challenges in shared SA within teams due to poor collaboration tools |
| **(Bolstad, et al., 2005)** | Military | Simulation | Experienced | 16 | SAGAT | Shared SA (similarity) | Shared knowledge and organizational hub distance predictive of Shared SA |
| **(Bonney, 2016)** | Business | Microworld | Students | 823 | SAGAT | Shared SA similarity (number of matches) | Team performance predicted by Shared SA and Shared strategy. High SA teams benefited from greater variance in SA across the team. |
| **(Brooks, Switzer, & Gugerty, 2003)** | Process control | Simulation | Experienced | 24 | SAGAT | Combined Team SA Score | Not sensitive to a 5 minute "SA training" video |
| **(Cooke, Stout, Rivera, & Salas, 1998)** | Helicopter | Microworld | Students | 24 | SAGAT, SPAM | Combined Team SA Score | Team Knowledge accuracy predicted Team SA (.762, .781, .772, .690). Team SA also predicted by role knowledge (.677,.676 ) and non-role knowledge (.753). Shared knowledge decreased over time |
| **(Cooke, Kiekel, & Helm, 2001)** | UAV | Simulation | Students | 33 | SPAM | Combined Team SA Score; Shared SA (similarity) | Team performance predicted by Team SA accuracy (r = .88) and SA similarity(r=.22) for L1 and L3 queries |
| **(Coolen, Draaisma, & Loeffen, 2019)** | Medical | Simulation | Experienced | 96 | SAGAT | Shared SA similarity | Consensus on problem and on diagnosis both highly predictive of time to goal achievement |
| **(Crozier et al., 2015)** | Medical | Simulation | Experienced | 12 | SAGAT | Combined Team SA Score; Shared SA; Complimentary SA | Team SA and Complimentary SA higher for more experienced teams; Team SA highly correlated with checklist performance (r = .995) |
| **(Cuevas & Bolstad, 2010)** | Military | Simulation | Experienced | 19 | SAGAT | Team agreement with leader | Team leader SA is significant predictor of Team SA (r = .348) 12% of variance |
| **(Cuevas & Bolstad, 2010)** | Military | Simulation | Experienced | 25 | SAGAT | Team agreement with leader | Too much missing data for analysis, trend towards Team leader SA as predictor of Team SA (r = .612) |
| **(Cuevas & Bolstad, 2010)** | Military | Simulation | Experienced | 6 | SAGAT | Team agreement with leader | Team leader SA is significant predictor of Team SA (r = .698) 49% of variance |
| **(Jones & Endsley, 2002)** | Military | Simulation | Experienced | 10 | SAGAT | Shared SA | Method for determining shared SA from SAGAT scores |
| **(Gardner, Kosemund, & Martinez, 2017)** | Medical Trauma | Simulation | Novices | 43 | SAGAT | Combined Team SA Score | Team SA significantly predicted teamwork ratings for both the first scenario (*F*(1,9)=8.02; *P*<0.05; *R* 2=0.50) and the second (*F*(1,9)=9.94; *P*<0.01; *R* 2=0.55) scenario |
| **(Hallbert, 1997)** | Process Control | Simulation | Experienced | 8 | SACRI | Collaborative Team Response | Teams with low SA had higher variance in SA scores (r= - .7 to- .9); SA at high workload affected by degree of team interaction |
| **(Javed, Norris, & Johnston, 2012)** | Emergency Management | Simulation | Experienced | 16 | SAGAT | Shared SA (SA similarity); Team SA (queries about team member's L2 and L3); Combined scores across all three measures | Individual SA, Shared SA and Team SA all improved by new display concept. Combined scores also improved by display |
| **(Morgan et al., 2015)** | Medical | Simulation | Experienced | 15 | SAGAT | Combined Team SA Score | Correlation with performance (outcome times) in correct direction but not significant |
| **(Parush, et al., 2017)** | fire fighting | Simulator | novices | 42 | SAGAT | Shared SA (similarity and correctness) | SA was higher for individuals working alone than when in teams; Shared SA (both correct) was 41%; non-shared SA was 37.5%; strong relationship between SA and performance, particularly at lower levels of SA |
| **(Price & LaFiandra, 2017)** | Military | Microworld | Experienced | 28 | QUASA | Collaborative Team Response | Stress affected Team SA scores, high stress doubled the level of overconfidence in the teams; higher team engagement lowered stress |
| **(Prince, et al., 2007)** | Aviation | Simulation | Novice | 41 | SAGAT; Implicit performance measure | Combined Team SA Score | Team SA predictive of emergency performance (r = .46). TSA and Implicit behaviors correlated (r = .43) |
| **(Rosenman et al., 2018)** | Medical | Simulation | Novice and Experienced | 123 | Post trial SAGAT - L3 only | Shared SA similarity | Correlated with team performance measure (r=.32) |
| **(Sætrevik, 2012)** | Emergency Handling | Simulation | Experienced | 45 | SAGAT | Team SA Similarity (Team agreement with Leader) | Not sensitive to team membership, numbers of team meetings, or the time since the last meeting |
| **(Saner, Bolstad, Gonzalez, & Cuevas, 2009)** | Military | Simulation | Experienced | 17 | SAGAT | Team SA similarity (agreement and completeness) | Shared knowledge and organizational hub distance were predictive. |
| **(Seet, Teh, Soo, & Teo, 2004)** | Military | Live Exercises | Experienced | 9 | SAGAT | Combined Team SA Score; Shared SA (similarity): Complementary SA (any 1 correct) | No statistics provided; sample size too low |
| **(Sorensen, Stanton, & Banks, 2010)** | Intelligence Analysis | Live Exercises | Students | 34 | SAGAT | Median team SA | Did not discriminate between a hierarchical and peer-to-peer organizational structure |
| **(Sulistyawati, Chui, & Wickens, 2008) also (Sulistyawati, Wickens, & Chui, 2009)** | Military Aviation | Simulation | Experienced | 16 | SAGAT | SAGAT-self; SAGAT-Teammate | SAGAT scores highly predictive of survivability (r=.69) Teams with more overconfidence bias shot at more. (r=.68). SAGAT of own and teammates situation correlated (r=.6, p=.06). Over-confidence bias negatively correlated with SAGAT-self (r=-.85) |
| **(Yuan, 2016)** | Process control | Microworld | Students | 40 | SAGAT | SAGAT-self; SAGAT-Teammate | Strong negative correlation between SA of own tasks and SA of teammates tasks.; SA of teammate improved with display |

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