Generation versus Aging, and Education, Occupation, Gender and Ethnicity Effects in U.S. Digital Divides

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Abstract--**Information and communication technology (ICT) are often thought to hold the potential to level many societal barriers, e.g., those created by gender or ethnicity. Using the NSF Surveys of Public Understanding of Science and Technology (maximum *n* = 18125 adults), I track five generations born from 1891 to 1988 over periods from one to 28 years, juxtaposing how generation versus aging, coupled with gender, ethnicity, occupation and education, affected computer ownership and Internet access and use between 1983 and 2006. Using *n* way analyses of covariance, I found by 2006, adults who owned a computer went online from home. Although gender was less important in ICT access and use, significant divides by generation, occupation, education and ethnicity in PC ownership and selected online uses remain.**

I. INTRODUCTION

Information and communication technology (ICT) have quickly become indispensable: by 2006, 80% of U.S. adults were at least minimally involved with computers, cell phones or the Internet [1] and 75% of Americans over age 11 were online [2]. In 2006, 70 percent of workers said the Web increased their productivity [2]. Nevertheless, many Americans abstain from ICT. "Digital divides" refer to gaps in ICT access *and* use across individuals occupying different societal locations [3]. Past research indicates that men used ICT more than women, Whites more than African-Americans or Hispanics, science and technology ["STEM"] professionals more than other workers, the well educated more than those less so, and young adults more than the elderly, ([4]; [5]).

Even early on, governments, academics and commerce centers recognized ICT's potential to create greater societal equity. For example, ICT can increase skilled labor demand, thus creating opportunities for disenfranchised group members who possess digital skills. Although the same ICT divisions (race, gender, age) recur globally ([6]; [7]; [8]; [9]; [10]), the United States, with its historical gender, ethnic, and economic divisions, ideology of equality, and technological development, provides an appealing test case to track digital divides across generations.

Although age is often used as an ICT predictor, generation typically is not. Age is a conceptually unclear variable: is it life cycle processes? Slowed reflexes and learning? Or, as in "one-shot" studies, generational effects instead? In the spirit of "you can't teach an old dog new tricks," prior research implies that some unspecified aging process dampens digital use. Yet age and cohort are inevitably confounded when analyzing data at *one time point*, because earlier generations are simultaneously older adults. Such studies cannot disentangle whether the results reflect aging processes, whether youthful enthusiasm promotes ICT use, or whether recent cohorts simply have had more ICT exposure.

Thus, *I explicitly focus on how generation, combined with education, occupation, gender and ethnicity affects U.S. computer ownership and selected Internet uses*, *contrasting cohort effects with age.* I will show that the generation construct provides valuable information about adult digital divides and that earlier studies solely designating "age" mislead. Using the General Social Survey and the NSF Surveys of Public Understanding of Science and Technology I track five U.S. generations from one to 28 years. Narrowing divides across generations have policy implications for future digital equality.

If digital divides converge, or even vanish, among recent generations, technological benefits may now be more evenly spread throughout society. If "new adults", regardless

of other characteristics have comparable digital skills, employers who hire or advance women and minorities acquire desirable workers. Better quality employment for previously disadvantaged groups creates more social equality. However, employers may also hesitate to hire or promote older workers because they fear "seniors" lack digital skills and may be neither interested in—nor able to—acquire them. Due to age stereotypes older workers themselves may feel unable to learn such skills. If cohort is more implicated than age in ICT use, supervisors can no longer assume that by definition older workers are digitally deficient. But if divides are static, or widen by generation, then the U.S. may remain separated into digital have and have-nots for some time to come.

Research Questions

- How does generation versus age influence computer and Internet use?
- What are the effects of generation and age, net of variables such as gender, ethnicity, education, or occupation?
- What are some implications of widening or converging generational digital divides?

II. Background in brief

A. Gender.

U.S. computer innovators were college educated White professional and managerial men, although women clerical workers often performed data entry or word processing. Early Internet and broadband users were also affluent White men ([4]; [5]; [11]). By the mid-2000s, many U.S. gender digital divides had closed ([5]; [12]). Since professional, technical and managerial occupations often involve ICT, this is unsurprising because of women's educational and labor force gains, and greater concentrations in the life sciences during the late twentieth century [13].

In 2002 American employed women and men owned computers at roughly equal rates; by then most computer owners regardless of gender or employment status, went online [5]. STEM professionals or managers in 2002 also more often had work computer access, although men had greater Internet access. Recent studies report that the sexes go online in similar proportions, although the amount and type of usage varies ([2]; [12]). A considerable income gender gap remains, which is reflected in services consumption: women spend less time online and men more often have broadband ([13]; [14]).

Research indicates men more often view news, entertainment, weather, or finance news, or do employment research online; women more often access health, maps, religious sites and contact their children more often ([11]; [14]; also see review in [16]). Men are more familiar with technical terms (e.g., spyware [12]). However, greater gender similarities occur among current teenagers than among older adults in activities such as downloading files ([1]; [12]). *These "age differences" actually suggest fewer ICT gender gaps among recent generations*.

B. Ethnicity.

U.S. ethnic ICT cleavages continue (e.g., [4]). Hispanic and African-Americans are disproportionately offline ([2]; [17]). English fluency, U.S. nativity, and education are important determinants of Hispanic online use ([10]; [18]). Hispanic and African-Americans less often have home Internet or broadband [4].

Educational level intertwines with ethnicity, income and occupation. African-Americans and Hispanics more often cite cost as a factor in Internet access. Hispanics average less education and income than other U.S. ethnicities and African-Americans complete college less than Whites [13]. Fox and Livingston [19] found African-Americans lacking high school completion went online less than their White counterparts. Blacks and Hispanics are also disproportionately concentrated in inner city areas where broadband is less common or poor quality telephone lines make Internet experiences less satisfying (e.g., [20]; [21]).

On the other hand, 2007 *college graduates* had similar online access regardless of ethnicity [19]. *Young* Hispanic and African-American adults accessed the Internet in 2007 more often than earlier, although less than young adult Whites [19]. Horrigan [14] suggests the *rate of growth* among broadband subscribers has been higher among African-Americans and Latinos than among Whites. Cotten & Jelenewicz' [22] study of Southeastern college students reported few ethnic differences in ICT. However they reanalyzed a *Web survey* of freshmen *that were online to begin with*. Most apparently went online in dormitories, thus obviating family income factors. Finally, ([22]: pp. 499-500) they collapsed ethnicity into misleading White versus "non-White" categories, joining Asians, Blacks and Hispanics.

Asian Americans receive scant attention in digital divide research, perhaps because they are a small minority, making sample projections unstable. They are better educated than other U.S. ethnicities (nearly half graduate college), more often earn STEM degrees, have more income, and more often hold managerial, science, engineering, computer or mathematics jobs ([13]: Tables 217, 218, 598 and 786). For occupational reasons alone, Asian Americans should more often use ICTs.

C. Education and Occupation.

Education is the most consistent global ICT predictor. The college-educated adopt digital technology earlier [4]. They more often own computers, have home Internet and broadband, and spend more time online ([4]; [5]; [11]; [23]). Part of education's effect is from the demands and prerogatives in the skilled occupations well-educated workers occupy. These workers earn more, thus making computers or broadband affordable. Well-educated adults have more online familiarity and more experience evaluating information. Thus, they can better harness the Web to improve their skills, locate useful data, or purchase bargain goods or services ([11]; [23]).

Education may be able to surmount digital divides. *All* U.S. ethnic groups improved their educational levels over time ([13]: Table 217). However, those who *earn less* than college educated White men—women, Blacks and Hispanics, or seniors mistrust using credit cards or purchasing online ([11]; [12]; [18]; [19]). Unfortunately, most American adults lack even a two-year college degree. If digital divides widen across degree levels among more recent generations, the disparities only add to the increasing "have" of the college educated, contrasted with the "have-nots".

Occupational differences net of education affect what is termed the "second digital divide" ([24]; [25]; [26]): *use rather than access*. For example, largely female clerical workers use ICT for data entry or word processing. Retail sales workers may use "smart cash registers" but perform far fewer analyses or information searches than STEM workers (more often male) who routinely employ digital diagnostics, analyses, or syntheses. Many "other professionals" are female pink-collar workers in schools, medical offices, or service agencies. Medical assistants use ICT for testing, but their employers may not see Web access or email as enhancing their job performance. Despite emphases on digital resources, many schools have obsolete hardware or software, lacking speedy Internet connections ([27]; [28]).

Bosses may believe that blue-collar workers are unable to use digital resources and view Web access as tangential for these jobs. Mostly female service workers have little occasion for digital work. Service jobs also have high turnover, so employers may not bother to train incumbents in ICT. Losh [5] found that male STEM professionals more than other employees had work computers, job email and Internet access. Clerical or blue collar workers, and women "other professionals" lagged behind.

D. *Age versus Generation.*

Do the "age differences" consistently reported in ICT access and use reflect maturation or do they reflect unique experiences for specific generations that could affect digital divides? For example, midlife and senior citizens acquire new skills more slowly; once learned, however, younger and older workers perform similarly [29]. Although "seniors" more often claim to be offline because they are "not interested," current Baby Boomers, now aged 50 to 64 represent an ICT growth market [14]. On a "typical day" Fallows [30] found 40% of U.S. adults aged 50 to 64 used search engines, as did 27% of those 65 or older. Seniors (32%) were second only to 18 to 29 year olds (49%) in saying the Internet improved their connections to friends and the *most likely to say* it improved connections with family [15]: 26).

Young adults spend considerable time creating online social or romantic connections, combating tensions from school, and establishing a work life ([1]; [14]; [15]; [31]). Midlife adults more often do business online. "Everyone" except the very old uses email [32]. These kinds of differences reported globally are probably *age or life cycle*, rather than cohort related, social behaviors ([2]; [8]; [9]; [14]).

To examine generations, we must know when they begin and end ([31], [33]; [34]). Rather than using constant intervals, cohorts are usually constructed considering both time *and* significant events occurring when youth or adults could consciously experience them, e.g., "Millennials" born in the late 1970s to late 1980s would not have used "IBM cards". Generations differ considerably in ICT exposure and skills. Many adults born in the late nineteenth and early twentieth centuries had retired or died before widespread Internet availability. The "Lucky Few" [35] matured in the boom 1950s economy; due to free time during retirement and greater discretionary income this generation increasingly is going online. Because of the economic constraints adult "Baby Boomers" have faced, their equipment or broadband purchases have lagged somewhat, yet "Boomers" too are increasing broadband use [14]. "Millennials" have had the most youthful exposure to computers and the Internet.

These cohort—and possible age—ICT differences have implications for *other* digital inequalities. Are women overall slightly behind men in particular ICT uses because they are older as a group or is some form of "sex difference" involved, ([11]; [12])? Is ICT use lower among Hispanics because they are younger, thus less often have economic resources than middle-aged workers, or are other, more cultural, less transient, factors involved? These questions imply that multivariate controls are needed to disentangle just what particular digital divides really mean.

III. METHODS

A. The data

The most comprehensive series of American surveys about science and technology adult "literacy" are the National Science Foundation Surveys of Public Understanding of Science and Technology ([36]; [37]). The *1979-2006 NSF Surveys archive* comprises 23,906 unweighted interviews in 12 probability sample surveys. I use data on computer and information technology available for 1983, 1985, 1988, 1990, 1995, 1997, and 1999, Random Digital Dial surveys of U.S. adults plus the 2002 and 2006 General Social Survey (GSS), in-person probability area surveys.[1] Only GSS aduts with *any* telephone (95 percent of the total) are analyzed to maximize comparisons with the NSF data. This total case base *when all nine surveys are analyzed* is 18,125 adults 18 years and older.

Most analyses are more circumscribed. Data on PC ownership stretch from 1983 to 2006. Home Internet access and estimated annual online hours are available from 1995 to 2006. Data on online hours through 2002 were estimated *using the grand total from several questions* (e.g., home, work); only one item was available for 2006, making 2006 figures slightly lower than earlier estimates. Information about *the Internet as a primary source* for general and science news is only available for 2006 (three people relied on the Web for science news in 1995). Final sample sizes range from 1962

[1] The 2006 NSF data were gathered through the 2006 GSS.

(2006) to 18,125[2] and *n*s are referenced in tables and figures.

B. Generation and age categories:

One example of cohort debates is when the "Baby Boom" ends. Scholars agree it *began* in 1946 [35]. Some end it in 1957, when *birth rates* peak, others in 1961 when the *number of births* peaks. Since "Generation X" is generally agreed to begin in the early 1960s, I ended the Baby Boom in 1961, beginning "Gen X" in 1962. The created cohorts are: **Millennials,** sometimes called Gen Y, born 1979 to 1988; **Generation X** (1962 – 1978); **Baby Boomers** (1946 – 1961); **The Lucky Few** (1930 – 1945); and the **Early Years** (1891 – 1929).[3]

Pragmatically some cohorts here are small. I omitted 86 respondents born before 1891 because dementia rates rise after age 80, making later responses possibly unreliable. By 2006, cumulatively, 711 Millennials were age 18 or more. Pre WWI respondents (n = 1836) not only have aged (or died) by 2006, but many items were not asked until 1995, decimating their numbers further. For analysis (including cross-tabulations and analyses of covariance), I represent five age groups approximately corresponding to U.S. government use: 18-24; 25-34; 35-44; 45-64; and age 65 and over. Although age group and cohort positively correlate (r = 0.65) because older study adults tend to be from earlier cohorts, given 9 surveys and up to 28 years, there is still some independence between these two variables.

C. Background variables

Data on age, cohort, gender, occupation and education are available 1983 to 2006. Unfortunately, income data are unavailable for the NSF series. Data on ethnicity are available 1999, 2002 and 2006. Education was coded: at least some graduate school, baccalaureate, Associate of Arts or two year vocational degree, and at most a high school diploma. Occupation has six categories: science or technology professionals; other professionals; managers; clerical workers; blue-collar workers; and not in labor force. The rationale behind these categories is to capture nuances among white-collar workers who use ICT more overall than blue-collar employees. Ethnicity is coded: White; African-American, Asian and Latino or Hispanic[4] (not elsewhere classified)[5].

IV. Results

To set the stage, I present overall results across time. Next I discuss how ICT access and use vary by gender, ethnicity, education and occupation. *My final presented results compare generation versus age effects on computer ownership and online time, controlling gender ,education and occupation*.

Table 1 shows how computer ownership rose steeply from 1983 to 2006 ($X^2_{(8)} = 3093.32$, $p < .001$, $r = 0.41$). Table 2 shows how home Internet access for those with computers rose from 33% in 1995 to 100% in 2006 ($X^2_{(4)} = 2117.77$, $p < .001$, $r = 0.44$). Because by 2006 PC ownership was synonymous with home Internet, data on home Web access is not presented further.

Table 1: % U.S. Population Owning Computer by Time and Gender

% who own-	1983	1985	1988	1990	1995	1997	1999	2002	2006
all	7.6	14.8	18.5	22.2	36.6	42.5	53.9	58.3	68.8
Male	7.3	16.7	21.4	26.5	40.9	43.9	54.8	59.1	71.0
Female	7.9	13.1*	16.0*	18.3*	32.8*	41.3	53.0	57.7	67.1*
n	1645	2019	2041	2033	2006	2000	1882	2616	1817

*Comparisons by Gender that year, $p < 0.05$

Table *2:* % *Computer* Owners who have Home Internet Access

%	1995	1997	1999	2002	2006
home Internet access (all)	32.5	71.3	86.1	95.5	100.0
Male	37.4	79.2	90.4	95.6	100.0
Female	26.3*	62.7*	81.8*	95.4	100.0
n	418	453	610	1361	1250

*Comparisons by Gender that year, $p < 0.05$

Estimated annual online hours rose from 5.6 in 1995 to 316 by 2006 ($F_{4,10299} = 351.08$, $p < .001$, $\eta = 0.35$). In 2006, 14% of the sample used the Internet as their *major* news source, compared with 50% relying on television, 24% on newspapers and 6% on radio. Significantly more adults, 23%, accessed the Web as their primary *science* news source (paired t, 9.82 with n = 1818, $p < .001$); 41% watched television science news, 11% read newspapers, 11% read magazines, and only 2% largely obtained science news via radio.

Any narrowing of digital divides by generation is considered promising for those hoping that greater social equity will follow digital equality. Furthermore, such convergences could mean that employers can expect more uniform ICT experiences among recent cohorts regardless of gender or ethnicity. However, generational data are mixed. In a pattern to be repeated, Fig. 1 presents mean scores showing how PC ownership varied by cohort over time. Broad gaps opened across generations by 2006, with Baby Boomers and more recent cohorts more often owning a computer—and thus having home Internet. Time ($F_{8, 17971} = 355.17$, $p < .001$), cohort ($F_{4, 17971} = 543.45$, $p < .001$) and their interaction ($F_{27, 17971} = 13.33$, $p < .001$) effects were statistically significant (total $\eta = 0.46$; tests of statistical significance control gender, education and occupation).

Even among PC owners, cohort affected online time. Although all generations increased their online hours (main effect, year, $F_{4, 10241} = 272.45$, $p < .001$), Baby Boom, Generation X and Millennial adults increased their access the

[2] Data are weighted with a combination of gender, ethnicity, education, and region weights.

[3] The "Early Years" generation actually collapses two cohorts born prior to 1930 due to their decreasing numbers in the 2002 and 2006 data.

[4] A separate question asked respondents about Hispanic ancestry. For ethnicity, those coded Hispanic who gave no other information when asked a *general question* about ethnic identification are also included.

[5] Of course other variables have also been used as predictors, e.g., urban residence, and marital or parental status. Their use complicates these analyses given that very young adults generally are single and childless and many older individuals are widowed without young children.

most (main effect, cohort, $F_{4, 10241} = 34.48$, $p < .001$). Furthermore, similar to the cohort differences in computer ownership (Fig. 1), *generational gaps widened over time* (the year-cohort interaction, $F_{4, 10241} = 13.44$, $p < .001$). By 2006, Millennials and Generation X averaged 400 annual online hours, compared with 293 for Baby Boomers, 145 for the Lucky Few and 76 hours for those born before 1930.

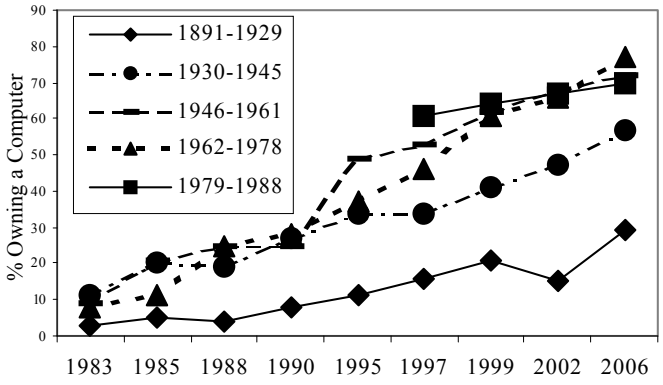

Fig. 1: Time & Cohort Effects on Owning PC

A. Gender and Ethnicity

Obviously adults *within* generations differ on many characteristics. In particular, I examine education, gender and ethnicity, which globally predict digital splits. I also analyze occupation, which is less often studied. At one point, gender was a primary digital divide. There are still U.S. sex differences in Internet *use* and these influence ICT access and customs globally ([8]; [9]). However, much gender convergence in U.S. PC ownership (thus also in home Web access, see Tables 1 and 2) has occurred.

This growing gender similarity in computer ownership and home Internet access also occurs for online time and accessing news. For parsimony, therefore, detailed results for these digital convergences are omitted[6] although I summarize the results. Men were online slightly more than women (all, 193 versus 162 hours; for Millennials, 359 versus 317; $F_{1, 10257} = 6.55$, $p = .011$). Millennial women accessed general online news slightly *more* than men (30 versus 28%) as well as science news (45 versus 39%). *Overall*, men ($F_{1, 1803} = 10.43$, $p = .001$) and more recent cohorts accessed Internet news more often (29% for Millennials versus 1% for the Early Years, $F_{4, 1803} = 33.54$, $p < .001$, η using education, occupation and ethnicity as controls = 0.36). Only a borderline overall sex difference occurred on science news ($F_{1, 1803} = 3.02$, $p = .082$) although there was a sizable cohort difference (42% for Millennials versus 3% for the Early Years, $F_{4, 1803} = 34.12$, $p < .001$, overall $\eta = 0.36$).

The news is mixed for generation and ethnicity. Analyses control education, age and gender (see below about occupation). Because Hispanic and African-Americans are younger than Whites, they may not yet have become economically established enough to afford a PC or Internet service. Sample Asian Americans had the highest educational levels (54% had at least a BA in 2006) compared with White- (31%), Black- (11%) or Hispanic Americans (5%; $X^2_{(9)} = 130.94$, $p < .001$). Recent cohorts more often owned a PC ($F_{4,6137} = 71.49$, $p < .001$) and Whites and Asians owned a computer more than Hispanics followed by Blacks (ethnicity $F_{3,6137} = 34.09$, $p < .001$). 73% of White and Asian American Millennials owned a home PC compared with 63% of Hispanics and 55% of Blacks.

Ethnic divides in online time can reflect income disparities. Thus White and Asian Americans should be online longer than Hispanic or African Americans. Ethnic differences in hours online continued (year, $F_{2, 6138} = 189.36$, $p < .001$; ethnicity, $F_{2,6138} = 3.69$, $p = 0.01$, total $\eta = 0.33$). Asians were online the longest, followed by White, Hispanic, and Black Americans relatively close together among Millennials. Fig. 2 depicts how ethnicity and cohort affect online hours. Ethnicity ($F_{3,6124} = 3.49$, $p = .015$), cohort ($F_{4,6124} = 22.37$, $p < .001$) and their interaction ($F_{12,6124} = 2.29$, $p = .007$, total $\eta = 0.26$ controlling age, education and gender), reflected the jump in connectivity among younger Asian Americans.

Asian Americans used the Web as their major source for general news (ethnicity, $F_{3,1721} = 4.80$, $p < .01$) more than other ethnicities and recent generations did so more than earlier ones ($F_{4,1721} = 31.76$, $p < .001$). Asian Americans (29%) referenced the Internet for news more than twice as often as Blacks or Whites (both 14%) or Hispanics (10%).

The picture is more complex for primarily accessing the Web for science news. That graph looks nearly identical to Fig. 2. Generation X and Millennial Asian Americans accessed Web science news most often, distantly followed by Whites, African-Americans and Hispanics. The main ethnicity effect was not statistically significant ($F_{3,1721} = 2.07$, $p = .102$) but cohort effects ($F_{4,1721} = 34.04$, $p < .001$) and the cohort-ethnicity interaction ($F_{12,1721} = 1.96$, $p < .05$, total $\eta = 0.33$) were.

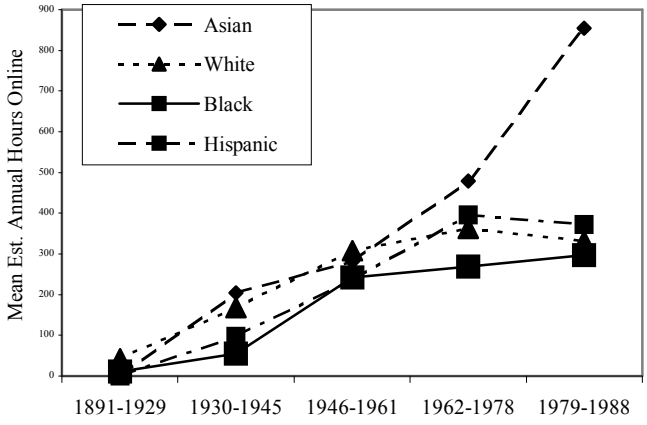

Fig. 2: Cohort & Ethnic Effects on Online Time 1999-2006

C. Education and occupation

Educational level has consistently predicted ICT

[6] Tables and graphs are available from the author upon request.

access and use, partly because baccalaureates more often hold jobs using digital technology, partly because they are wealthier, and partly because they are more cognitively prepared to utilize online opportunities. Among Millennials, adults with two-year degrees significantly progressed on PC ownership compared with earlier cohorts. However, the high school educated lagged behind: only 62% owned a computer, compared with 81% of Millennials with Associate degrees, 93% of baccalaureates and 89% with graduate school. Net main effects for education ($F_{3, 17982} = 409.87$, $p < .001$), cohort ($F_{4, 17982} = 801.33$, $p < .001$), and their interaction ($F_{12, 17982} = 2.10$, $p < .05$, total η including covariates gender and age = 0.46) were all statistically significant.

Online time varied by education and generation, providing another example (see Fig. 1 for form) of how interactions ($F_{12, 10247} = 2.71$, $p < .001$) occur *because digital divides widened across time or across cohort*. A gap in online hours opened and widened between baccalaureates and those less educated. The division begins in the earliest cohort, then increases. Both cohort ($F_{4, 10247} = 121.44$, $p < .001$) and degree ($F_{3,10247} = 88.70$, $p < .001$, total η including covariates = 0.27) main effects occur as well.

The picture is similar for how cohort and degree affected 2006 news access (the only study year for which data are currently available); Given differences in online time by generation and education, the interaction effects for accessing regular news ($F_{12, 1793} = 4.50$, $p < .001$) and science news ($F_{12, 1793} = 2.65$, $p = .002$) are consistent. The better educated ($F_{3, 1793} = 28.20$, $p < .001$), and Generation X and Millennials ($F_{4, 1793} = 32.39$, $p < .001$, total η with gender as a covariate = 0.33)[7] most often accessed Web news, and differences widened by education among recent cohorts. Comparable main effects for degree ($F_{3, 1793} = 27.44$, $p < .001$) and cohort ($F_{4, 1793} = 33.04$, $p < .001$, total η with gender as a covariate = 0.33), as well as greater educational digital gaps among recent cohorts, also occurred for accessing Internet science news. The largest differences were between those with at least a baccalaureate and those with less education.

Predictably, (adjusted for age, generation, gender and education) STEM professionals were the greatest ICT consumers. Over the *total* 1983-2006 period, 59% owned computers, compared with 47% of managers, 38% of other professionals, 42% of clerical workers, 32% of blue-collar workers, and 36% of those not in the labor force ($F_{5, 17988} = 50.20$, $p < .001$). Among STEM professionals a whopping 93% of Millennials owned computers compared with 74% of Generation X and 60% of Baby Boomers (cohort, $F_{4, 17988} = 601.76$, $p < .001$). At 859 estimated annual online hours, STEM professionals logged nearly twice as many hours as managers (477) or other professionals (412), and considerably more than clerical (391) or blue collar (225 hours) workers, or nonlabor force (219 hours) adults (occupation, $F_{5, 10253} = 52.98$, $p < .001$). STEM professionals most often accessed online general news (37%, $F_{5, 1728} = 6.84$ $p < .001$) and 57% primarily accessed science news online ($F_{5, 1728} = 8.97$ $p < .001$), nearly twice as many in either case as any other occupational category.

Controlling occupation shrinks ethnicity effects. The gap in PC ownership dropped from 31% (Asians 74% Whites 63% Hispanics 54% African Americans 43%) adjusting for education and, especially, occupation, to 18% ($F_{3, 6141} = 36.11$, $p < .001$). The average difference in online hours between Asians and African-Americans (the two "extreme" groups) shrank from 252 average hours to 140 ($F_{3, 6138} = 3.50$, $p < .001$). In the adjusted percents, 23% of Asians accessed general news online, compared with 14% of Whites, 15% of African Americans and 9% of Hispanics. The net effect of ethnicity on accessing science news was not statistically significant ($F_{3, 1728} = 1.88$ $p = .13$).

D. Age versus Generation and Digital Divides

A striking similarity occurs in contrasting age with generational effects on digital technology. Fig. 3 and Fig. 4 show these effects controlling gender, education and occupation.[8] In both cases, although results contradict "conventional wisdom" about "aging" they are, in fact, eminently sensible: controlling age, each successive cohort more often owns a computer ($F_{4, 17988} = 607.76$, $p < .001$) and spends more hours online ($F_{4, 10253} = 106.92$, $p < .001$). However, controlling generation, with each age increment, adults *more often owned computers* ($F_{4, 17988} = 206.71$, $p < .001$) and *spent more hours online* ($F_{4, 10253} = 32.24$, $p < .001$).

Why are these effects of age (controlling cohort) so sensible? Because older adults more often have accumulated the financial resources to afford computers and the broadband services that generally result in more time online. The economic capital that many middle-aged and senior adults have accumulated (that also purchases ICT tutoring if necessary) is virtually always overlooked in previous research, which extols the virtues of "the young" (i.e., recent generations) who matured with ICT and are at ease acquiring new digital skills. Clearly both generation *and* age positively affect at least some ICT dimensions.

V. DISCUSSION, CONCLUSIONS, IMPLICATIONS

Coupled with other current research, these results indicate some American digital gaps are closing. By 2006 virtually all computer owners had home Internet access. Rough gender parity occurred in computer ownership, Internet access, approximate online time, and using the 'Net as a primary news source. Perhaps women's greater labor force participation in the life sciences has increased ICT's appeal. As the cited literature suggests, women also use the Internet to solidify social ties, and this, too, can contribute to closing the gender digital divide.

[7] Age group is not a covariate in 2006 analyses because of its overlap with generation in a single year.

[8] To maximize the case base, race (available only from 1999 on) is not included as a factor for PC ownership or online hours. Note that controlling occupation also controls many of the effects of race-ethnicity.

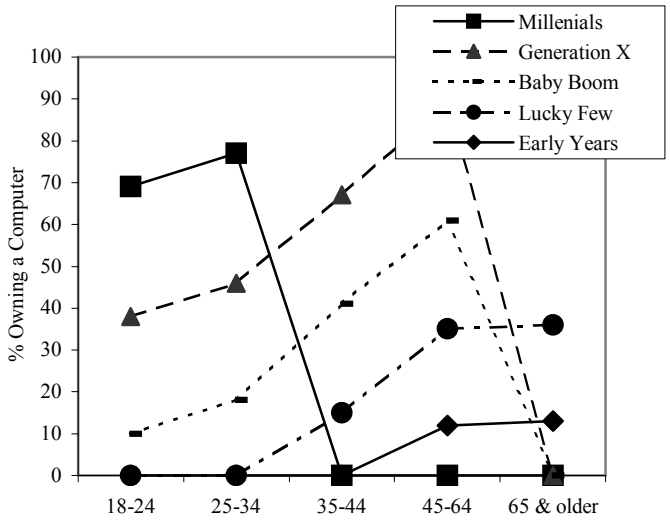

Fig. 3: % Adjusted Age & Cohort Effects on Owning PC

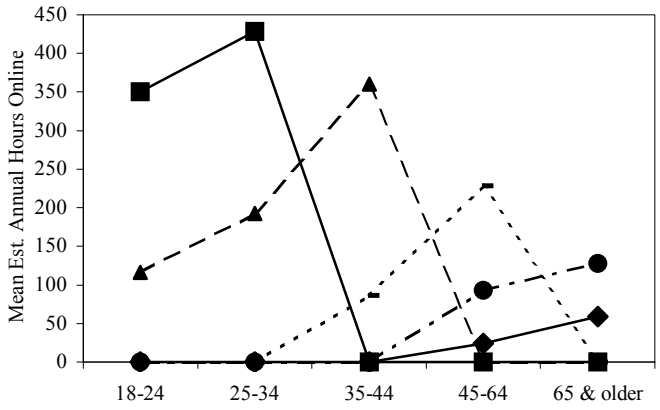

Fig. 4: Adjusted Cohort & Age Effects on Online Time

Probably through early ICT experiences, recent cohorts are more digitally comfortable: typically owning a PC and logging more Web time. In larger numbers than prior generations they access news on the Web. Indeed, many U.S. newspapers are increasingly parochial, printing local news, apparently assuming better-educated readers obtain national and international news online, or else they simply stop print editions,[9] inadvertently robbing earlier generations—now older people—of their traditional window on the world.

Considerable educational, occupational, generational and ethnic ICT divisions remain. By the early 2000s, computer ownership was disproportionately concentrated among better educated White and Asian Americans. More recent generations, who have only an Associate's or a high school degree fell behind baccalaureates. ICT educational differences actually *widened* by cohort. Educational gaps across cohorts suggest disparities will continue in the near future. STEM workers also were heavier ICT users.

Asian Americans typically are either omitted from American digital divide research or are collapsed in a generic, misleading "non-White" category. Because of their work and educational work achievements, greater digital involvement among Asian Americans is predictable; greater participation of African- and Hispanic Americans in college, and in STEM jobs ultimately should create more equitable digital resources (and vice-versa). For example, when I controlled occupation, ethnic differences narrowed or vanished.

Clearly, the generational construct is useful to frame digital divides; earlier research using only the variable "age" is vague and confusing. Most strikingly, controlling cohort, age neither retards computer nor Web access the way prior research asserts. *What has been treated as age in one-shot surveys or in a few surveys over short time periods is almost certainly generational effects instead.* Because age and cohort overlap in short-term studies, it has been difficult to establish their separate effects. With the 28-year span here for PC ownership or the 12 years for home Internet or online time over several different surveys, we can begin disentangling age from generational influences. The *positive* effect then found of age may reflect greater income among midlife or older adults who are more occupationally established and thus better able to afford computers or the recurrent costs of Internet connections. There is no reason to expect adults to discontinue their email use, search engines, or online bargain hunting simply because they age. Nor should employers assume older workers are digitally inept.

The widening ethnic and educational digital gaps by generation are disturbing. The less educated, or African- or Hispanic Americans, can less often search or apply for jobs online, take online courses to upgrade their skills, locate health information, exploit bargains on purchases, or benefit from constant Internet news updates. Employers may expect less from these colleagues or employees, which can damage future prospects for employment or advancement among these groups. In sum, although American gender digital gaps are less, in an era when ICT access and use have become increasingly critical, significant differences in computer and Internet access, falling along prior social stratification cleavages, remain; many of these groups were economic "have-nots" during the twentieth century. Thus, as we head into the twenty-first, the promise of information technology to benefit traditionally disadvantaged demographic groups and provide a more level playing field for academic and economic marketplace achievement is only partly being fulfilled.

[9] In Fall 2008, the prestigious *Christian Science Monitor* announced it would only publish an online edition. The *Detroit News-Free Press* discontinued home delivery and the Chicago *Sun Times* filed for bankruptcy. Given rising publication costs in a poor economy it is likely that many U.S. newspapers will soon follow suit.

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