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ORIGINAL PAPER

Social capital in the creation of AI perception

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Abstract

Numerous studies over the past 30 years have examined the relationship between social capital (SC) and information and communication technology (ICT). However, few studies have examined the association between artificial intelligence (AI) and SC. This study addresses this gap using a Web survey ($n=5000$) carried out in the Tokyo metropolitan area in Japan in 2018. The survey included questions on ICT literacy and SC (networks, trust, norms of reciprocity), as well as questions on perceptions of AI including its impact on society. Based on the survey, we extracted four SC factors: cognitive SC, and three forms of structural SC, namely contacts with others, group participations, and SC at work place. We found a statistically significant positive association between SC and positive perceptions of AI through ITC literacy. SC is indirectly associated with AI perception by enhancing ICT literacy, and then ICT literacy enhances AI perception. This indirect effect seems to be mainly caused by two types of structural SC: SC through group participations and SC at work place. Besides this indirect effect, SC has direct effect on AI perception. Cognitive SC has direct positive association with AI perception, whereas structural SC in the form of contacts with others was negatively associated with AI perception. Thus, structural SC has an ambivalent effect on AI perception. Structural SC through group participation as well as SC at work place may work for the positive perceptions of AI through ICT literacy, while those with higher level of contacts with others tend to be cautious toward AI. Both cognitive SC and structural SC assume important roles for the smooth transition into the AI era. Policy makers should be aware of the difference in the way each of these SC forms affects AI perception. SC seems to have mainly promotional impact on the AI perception. However, the precautionary function of SC should not be put on the back burner for the sound social acceptance of AI. In any case, SC assumes an important role in the creation of AI perception.

Keywords Social capital · ICT · AI · Networks

Communicated by Takahiro Hoshino.

The title is inspired by Coleman (1988).

Extended author information available on the last page of the article

1 Introduction

Although we are moving into an era where Artificial Intelligence (AI) is fast becoming the norm, many of us are still at a loss about what AI can and will bring to society at least in Japan. This is clearly illustrated by the results of a survey ($n=5000$) we conducted in 2018, which asked respondents about the impact of AI on society.[1] Our survey focused on seven items, namely whether AI will make us happier, strengthen or weaken human relations, enhance or control our lives, free us from hard work or make us poor, enhance or deprive us of our creativity, make our society crime free or place it under heavier surveillance, and decrease or increase economic inequality. To our surprise, most respondents ($n=5000$) offered negative views on all seven items except for one, namely the availability of information. Four out of five respondents expected economic inequality to increase. In light of these results, it seems important to mitigate these pessimistic views by enhancing the social acceptance of AI prior to its implementation in society. This paper aims to address this issue by examining the association between AI perception and social capital (SC) through the use of information and communications technology (ICT) as an intermediary. SC can be affected by AI and is also a prerequisite for the social acceptance of AI. This study used the abovementioned survey ($n=5000$) that was carried out in the Tokyo metropolitan area in Japan in 2018. The survey asked questions on ICT literacy and SC (networks, trust, and norms of reciprocity), and on perceptions of AI among the respondents.

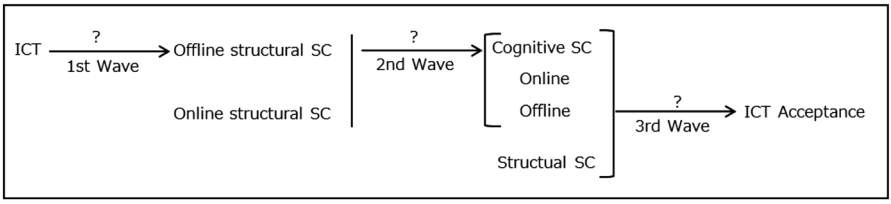
Definitions of SC differ among researchers (Bourdieu 1986; Coleman 1987, 1988; Burt 1992; Putnam 1993, 2000; Woolcock 1998; OECD 2001; Lin 2001; Bowls and Gintis 2002; Ostrom 1999; Ostrom and Ahn 2009). For this paper, we followed Inaba (2005), who defined SC as "trust, norms of reciprocity, and networks with externalities through human minds." Since externalities can be negative, this definition includes the negative aspects of SC as well. Networks are often called structural SC, trust and norms are called cognitive SC, SC that connects people with different backgrounds is called bridging SC, and SC that connects people with the same background is classified as bonding SC.

This study defines AI in line with the definition provided by the Japanese Society for Artificial Intelligence (Ishizuka et al. 2017, p. 2): "AI is computer systems with intelligent capabilities equivalent to human beings to infer, recognize and judge."

The rest of this paper is organized as follows. We begin with a survey of previous studies on SC and ICT to identify our research strategies. Then, we implement the research strategies using the data collected through our survey. First, factor analyses are conducted to identify the basic factors pertaining to SC, ICT literacy, and perceptions of AI. Second, we analyze the association between SC and AI perception via ICT literacy. Then, we proceed to analyze AI perception using SC and ICT literacy as explanatory variables.

[1] The details of the survey are described in Sect. 3.1.

Table 1 Three waves of preceding studies



2 Previous studies and research questions

There have been numerous studies on the relationship between SC and the use of ICT such as email, social networking services (SNSs), blogs, bulletin boards, knowledge collaborations, and video-sharing systems (Putnam 2000; Wellman et al. 2001; Yang et al. 2009; Ahmed 2018; Suda 2018). As seen in Table 1, these studies appear to have occurred in three waves, reflecting the increasing use of and progress in ICT. The first wave focused on the impact of ICT on the structural side of offline SC, namely activities related to the networks in the real world. When the second wave began in the 2000s, research shifted its focus onto the impact of ICT on the cognitive side of both online and offline SC including the norms of reciprocity and trust, both in the virtual and the real worlds. Over the past decade, the third wave seems to have dealt with causality from SC to the penetration of ICT rather than vice versa.

2.1 Previous studies

2.1.1 First wave

The first wave, which continued until the middle of the 2000s, focused mainly on the impact of ICT on the structural side (networks) of SC offline. It focused on whether ICT use complemented the existing offline structural SC or functioned as a substitute for it.

Wellman et al. (2001) examined the impact of the Internet on structural SC based on the data of 39, 211 North American adult participants of a survey conducted by the National Geographic Society in 1998. They found that the interactions online supplemented both face-to-face and telephonic communications without altering the extent of their occurrence. They could not find an association between Internet use and structural SC in the forms of face-to-face and telephonic communications except for the case in which heavy Internet use was associated with increased participation in voluntary organizations and politics. Their findings indicated partially complementing effects of ICT on offline structural SC.

Nie and Erbring (2002) surveyed a randomly selected sample of 4113 individuals in the US in 1999 and found that Internet use was negatively associated with the amount of time the respondents spent with their family and friends, and the time

they spent on events outside home. Thus, they concluded that Internet use may have had a negative impact on offline structural SC.

Norris (2003) investigated the following research questions in relation to the impact of the Internet on offline structural SC.

> "How do traditional communities overlap and interact with virtual social networks? Can online communities become substitutes for traditional forms of collegiality and social interaction based on traditional face-to-face contact in families, firms and local communities?" (Norris 2003, p 2).

Norris addressed these research questions in an empirical study using data from the Pew Internet and America Life Survey conducted in 2001, and found that "online contact did bring together like-minded souls, who share particular beliefs, hobbies or interests…Equally importantly, the joining of many different types of online groups was also perceived to broaden social contacts" (Ibid.). This means that online contact complemented existing offline bonding SC, and also functioned as a substitute for existing offline networks by expanding and bridging SC through the Internet. Norris found that the Internet had a slightly stronger impact on offline bonding SC than on offline bridging SC.

Kobayashi and Ikeda (2006) also explored the possibility that online SC would have a positive effect on offline structural SC. They conducted two web-based surveys using players of the MMORPG "LINEAGE," which involved multiple strangers ($n^{W1} = 1801$, $n^{W2} = 1365$). They found that after controlling for gender, age, educational attainment, household revenue, employment, and disposal time of respondents as well as offline SC, online reciprocity within the LINEAGE community promoted social participation in offline communities. This supports the finding that ICT functions as a complement to existing structural SC in the offline world.

Some studies shed light on personality. Ellison et al. (2007) suggested that Facebook may provide greater benefits for users experiencing low self-esteem and low life satisfaction by helping them bridge their SC. Their conclusion was shared by Terashima and Miura (2013) in which the authors found that SNS usage by those with low sociability were more likely to affect their online bridging SC. Kim et al. (2013) examined how social media use affected individuals' discussion network heterogeneity and their level of civic engagement. Their results supported the notion that the use of social media contributed to the heterogeneity of discussion networks and activities in civic life. They also found that the contributing role of social media in increasing network heterogeneity and civic engagement was greater for introverted and less open individuals.

The question whether ICT use could complement or substitute structural SC has remained valid, and subsequent empirical studies have approached it by expanding the scope of their studies into many other situations including Ryan (2010) who found that ICT use increases SC in healthcare; Zhong (2014) who found that SNS had a positive impact in enhancing online bridging and bonding SC and had a limited impact on offline bonding SC; Bauernschuster et al. (2014) who found that the Internet had a positive impact on SC index that was mainly composed of structural SC based on nationwide data from Germany; Li and Chen (2014) who found that SNS functioned as both a complement and/or a substitute depending on the location

of ties; and Nolan et al. (2015) who concluded that SNS enhances the social ties of "adolescent mothers," and thus complements existing SC. Most studies have indicated that ICT use enhances online structural SC and has a somewhat smaller impact on offline SC.

Some researchers extended the scope of their studies to examine the negative aspect of SC in ICT use. Habuchi (2005, p. 167) studied mobile technology and observed that "a zone of intimacy in which people can continuously maintain their relationships with others who they have already encountered without being restricted by geography and time." She defined "the small enclaves of like-minded clusters" as a tele-cocoon. Gergen (2008), Ling (2008), and Campbell and Kwak (2012) followed suit with a natural extension of the concept of tele-cocoons together with their empirical findings, all of which brought about the tele-cocooning hypothesis, which Kobayashi and Boase (2014, p. 682) described thus: "if texting facilitates contact with close friends and family exclusively, and if it reduces heterogeneous encounters, it can have a cocooning effect by focusing one's attention on existing close relation at the expense of reaching out to new people." The hypothesis suggests a trade-off between offline bonding SC at the price of offline bridging SC through the use of ICT.

Despite the large volume of previous empirical work, the basic research question on whether ICT use complemented existing offline structural SC or functioned as a substitute for it has not been fully answered yet. There are two schools of thought as described by Wellman et al. (2001), one each for the substitute and complement hypotheses. Both hypotheses are plausible enough. The results of preceding empirical works have been mixed. However, at least, as originally suggested by Putnam (2000) and Norris (2003), and the cocooning effect, ICT use seems to bring about a trade-off by somewhat enhancing offline bonding SC at the expense of offline bridging SC. SNSs may also have a positive impact of enhancing one's bridging SC in the cases of those with somewhat reserved personalities.

2.1.2 Second wave

The second wave of studies, which commenced in the mid-2000s, expanded the scope of the literature to include cognitive aspects (trust and norms) of offline SC, with academic interest shifting toward the relationship between the online cognitive SC created by ICT and offline cognitive SC. For instance, Miyata (2005a, b, c) and Miyata et al. (2005) conducted comprehensive studies on the impact of the Internet on SC using panel datasets based on three panel surveys in Yamanashi Prefecture in Japan between 2002 and 2005 ($n^{W1}=1002$, $n^{W2}=646$, $n^{W3}=432$). She found that continuous participation in online communities could diminish cognitive SC in the form of generalized trust, or at least fail to enhance the generalized trust of participants in online communities. Conversely, emails sent from cell-phones had an insignificant impact on online generalized trust, while emails sent from PCs increased online generalized trust. Miyata also analyzed the changes that occurred among the three surveys and found a spillover effect of online generalized trust to offline generalized trust through an increase in generalized reciprocity. Thus, ICT was found to affect offline cognitive SC.

However, there are more pessimistic views on the impact of ICT on society as a whole. Tsuji (2014) analyzed the impact of mobile media on cognitive SC (generalized trust and the norms of reciprocity) using the results of their mobile media surveys conducted in 2001 ($n=1876$) and in 2011 ($n=1452$). He found no association between the norms of reciprocity and ICT use. Although he found a partial association between Internet use through PCs and online generalized trust, no association was observed between ICT use and offline generalized trust.

Salahuddin et al. (2016) analyzed the effects of the Internet and real GDP per capita on the creation of trust in Australia between 1985 and 2013 and obtained mixed results. They found that Internet use reduced SC in the long run, but enhanced it slightly in the short run.

Although there is some uncertainty around the impact of ICT use on cognitive SC, especially generalized trust (trust in society as a whole), it generally seems to enhance online cognitive SC in small networks such as university classes. Lu et al. (2013) analyzed data from online classes and found that ICT use in the form of online learning facilitates SC formation, mostly in terms of trust, collective action, and cooperation among class members.

2.1.3 Third wave

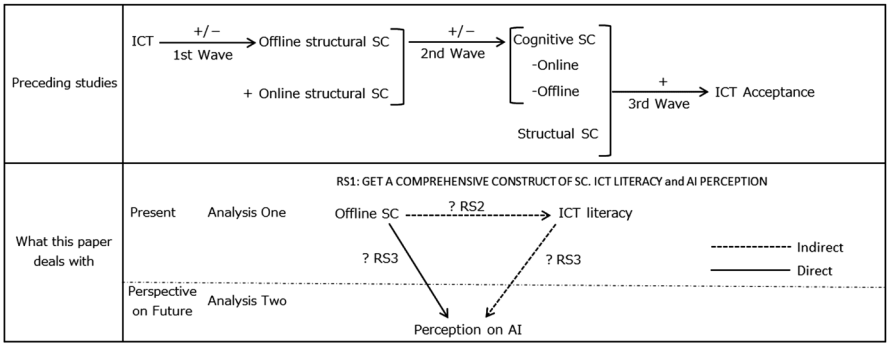
The third wave commenced in around 2010, reflecting the diffusion of smart phones. Studies during the third wave analyzed the penetration of ICT into daily life by focusing on the impact of SC on society's acceptance of ICT, rather than vice versa.

Penard and Poussing (2010) analyzed data from a survey of 1554 individuals aged between 16 and 74 years in Luxembourg in 2002 to identify the relationship between ICT and SC after taking opportunity costs in terms of time of IT users into account. Although their main research questions are the impact of ICT on SC, they also found that individuals with a large stock of SC are more likely to use the Internet to maintain their existing SC. A high level of trust in others increases the probability of maintaining social capital through the Internet. In addition, they also found that those involved in many associations used the Internet more intensively. That is, people with a large stock of SC are likely to increase their use of ICT to maintain their existing offline SC. A rich SC environment fosters Internet use to maintain one's SC. That is, high SC brings about a complementarity between ICT and SC.

Kuo et al. (2013) examined the case of an ICT learning program for digital-illiterate and middle-aged females ($n=133$) in Taiwan. They found that female ICT beginners who valued social connections and relationships with their classmates and friends were encouraged to gain ICT skills because they got to learn and care for each other. The cooperation lasted after the program ended, and thus extended their personal networks in cyberspace.

Naranjo-Zolotov et al. (2019) examined the impact of SC on ICT use (focusing on the use of electronic participatory platforms, abbreviated to "e-participation") using data from a sample of 200 people collected in Portugal in 2016. They hypothesized that a high level of SC would have a positive effect on either intended or actual e-participation. They used "trust in local government," "feeling of identification as a citizen within the community," "social interaction between members of

Table 2 Three waves preceding studies and the scope of the present paper



a given community," and "reciprocity between members of the community" as SC variables. Of these, "identification" and "interaction" were significantly associated with e-participation, while "reciprocity" and "trust in local government" were not. Therefore, the impact of SC on ICT use in the form of e-participation was more likely to be affected by structural aspects of SC rather than cognitive aspects of SC such as trust and reciprocity.

Although ICT use can enhance online structural SC, its impact on offline structural SC depends on the situation and the content of the ICT. Until the mid-2000s, the introduction of ICT functioned as a complement to and/or a substitute for existing offline SC (first wave). Researchers also found that online structural SC created by ICT mainly enhanced offline cognitive SC of relatively small groups. However, the results seem to be mixed for large populations (second wave). Currently, offline SC backed up by online structural SC generally seems to have a positive impact on ICT acceptance in society.

2.2 Research strategies (RS)

In light of the trends in previous studies, this study adopts SEM. We assume that the three principle variables in this study, namely SC, ICT literacy, and AI perception are different in terms of tense. SC and ICT literacy belong to the present, while AI perception is related to the future. As shown in Table 2, the association between AI perception and SC/ICT literacy is different from that between SC and ICT literacy. The former deals with the association between a variable on future projections (AI perception) and variables related to the present (SC and ICT literacy); whereas, the latter only deals with the associations between variables in the present.

RS1 Grasp the comprehensive constructs of SC, ICT literacy, and AI perception.

Both SC and ICT literacy are multifaceted concepts. However, most preceding studies have focused on the impact of one particular type of ICT such as the use of SNS. This lack of comprehensive analysis is also evident in relation to previous studies on SC that have mostly been based on partial aspects of SC such as networks, trust, and norms. Therefore, in the first place, we grasp the

comprehensive constructs of both SC and ICT literacy. We also try to get a comprehensive construct of AI perception.

RS2 Confirm the association between SC and ICT literacy.

Studies in third wave have suggested mostly affirmative associations between SC and ICT literacy with the partial element of SC. The second step of our strategy is to confirm the association between SC and ICT literacy using more comprehensive constructs of SC and ICT literacy as obtained by RS1. Although AI covers areas that are wider than those covered by ICT, ICT is a gateway to the AI era as many devices and software used in AI are based on ICT. ICT provides an interface between AI and humans, and thus functions as an intermediary between SC and AI perception. RS2 is, thus, a step to find out the indirect impacts of SC on AI perception through ICT literacy. In other words, we test the validity of the contents, namely factors obtained through the explanatory analyses using the results of the preceding studies mainly in the above-mentioned third wave studies.

RS3 Find out the association between AI perception and ICT literacy/SC.

SC can have a direct impact on AI perception as well. Trust and norms of reciprocity on society as a whole, which are important elements of SC, may alleviate pessimistic perspectives on AI. Networks can either promote or alleviate the formation of pessimistic AI perception. Homophily caused by bonding SC tends to create strong ties among the members of a group and may promote exclusive activities toward non-members. In this case, SC can lead to pessimistic views. On the other hand, heterophily derived from bridging SC may provide people with opportunities to come in contact with various kinds of people which may make them more generous toward new technologies including AI. RS3 tries to find this direct impact between SC and AI perception and that between ICT literacy and AI perception.

RS4 Draw policy implications.

What are the policy implications of the enhancement of the social acceptance of AI?

3 Materials and methods

3.1 Data

The dataset used in this study was obtained from a web-based survey conducted between September 4 and 10, 2018. The survey sample included residents aged between 20 and 69 years living in the Tokyo metropolitan area including Tokyo, Kanagawa, Chiba, and Saitama prefectures. Responses were received from 5000 people, as seen in Table 3.

The questionnaire included items on the following topics.

1. ICT literacy.

Table 3 Survey on the impact of AI: descriptive statistics

	N	%	Std.	Range
Sex				
Male	2502	50.0		
Female	2498	50.0		
Age (years)	5000	Mean 44.80	13.9	20–69
Educational attainment				
Junior high school	91	1.8		
Senior high school	1162	23.2		
Junior college/technical college/vocational school	1073	21.5		
University	2374	47.5	Mode	
Graduate school	292	5.8		
Other	8	0.2		
Annual income (million yen)				
None	67	1.3		
< 2.00	311	6.2		
2.00–3.99	764	15.3		
4.00–5.99	946	18.9		
6.00–7.99	637	12.7		
8.00–9.99	497	9.9		
10.00–14.99	422	8.4		
≧15.00	185	3.7		
Do not know/no answer	1171	23.4	Mode	
Dwellings				
Detached house	2040	40.8	Mode	
Condominium	1158	23.2		
Public housing	142	2.8		
Municipal housing	43	0.9		
Apartment	1431	28.6		
Company house/dormitory/civil servants housing	117	2.3		
Other	69	1.4		
Occupation				
Professional	649	19.8		
Administrative and managerial	389	11.9		
Clerical	1176	35.9	Mode	
Sales	266	8.1		
Service	459	14.0		
Manufacturing process/labor/security	318	9.7		
Agriculture/forestry/fishery	15	0.5		
Employment type				
Temporary employee/part-time/albeit	664	20.3		
Temporary/contractor/contract work/commissioned work	361	11.0		
Regular staff including public servants and teachers	1801	55.0	Mode	
Self-employed worker or family worker	297	9.1		

Table 3 (continued)

	N	%	Std.	Range
Manager/corporate officer/organization officer	102	3.1		
Other	47	1.4		

As seen in Table 4, we included 36 questions on ICT literacy. We had:

- 8 questions on access to ICT devices and PC (yes or no),
- 14 questions on the frequency of use of ICT devices and web services, measured using a three-point Likert scale,[2]
- 8 questions on the capability of PC and software and web usage, measured using a four-point Likert scale, and
- 6 questions on experience using AI-related equipment, measured using a three-point Likert scale.

2. SC

   As seen in Table 5, we asked 12 questions on SC. We had:

   - 8 questions related to structural SC including group participation, and relationships with neighbors, family members, relatives, friends and acquaintances, and colleagues, measured using four- to seven-point Likert scales, and
   - 4 questions related to cognitive SC including trust and norms of reciprocity, measured using a four-point Likert scale.

3. Perceptions of AI

   As seen in Table 6, there were 30 questions on respondents' perceptions of AI: the social influence of AI, whether the respondents have affirmative or negative opinions on AI in specific situations, the respondent's personal intention to use AI in specific applications, and the respondent's choices between AI and human beings in seven applications. We had:

   - 7 questions on the social influence of AI, 1 measured using a five-point Likert scale and 6 measured using a four-point Likert scale from the perspective of whether AI will make our society better or worse,
   - 8 questions on opinions on personal preference(the pros and cons of AI use in specific situations) of the respondents, measured using a five-point Likert scale,
   - 8 questions on impact on society of AI use in 8 specific situations, measured using a five-point Likert scale, and

[2] Refer to Inaba and Yoshino (2016) for the appropriateness of the use of the Likert scale.

Table 4 Factor analysis of ICT literacy: factor loading

		Factor				
		PC and software use capability	Access to ICT device/PC use	Frequency of information exchange/retrieval	AI-related device use	Software use-word processors and spreadsheet
Factor contribution		5.631	3.922	4.658	3.161	2.677
q1_1	I have a DVD BD HDD	−0.153	0.459	0.106	0.109	0.016
q1_2	I have a digital camera	−0.083	0.557	−0.024	0.131	0.044
q1_3	I have a console for games	−0.017	0.244	0.076	0.232	−0.061
q1_4	I have a radio clock	−0.056	0.524	−0.093	0.144	0.024
q1_5	I have IoT consumer electronics	−0.020	0.350	−0.060	0.356	−0.049
q1_6	I have a PC/tablet	0.093	0.559	0.056	−0.135	−0.012
q1_7	I have access to wireless LAN	0.074	0.430	0.063	0.152	−0.039
q1_8	I have access to pay TV/Internet TV	−0.073	0.296	−0.016	0.266	0.006
q2_1	Use frequency of smartphone	−0.040	−0.161	0.273	0.227	0.070
q2_3	Use frequency of PC	0.218	0.461	0.010	−0.184	0.040
q2_4	Use frequency of tablet	0.136	0.147	0.026	0.264	−0.062
q2_5	Use frequency of printer/MFP	0.029	0.571	−0.039	0.024	0.045
q2_6	Use e frequency of Bluetooth device	0.154	0.170	0.007	0.318	−0.045
q2_7	Use frequency of news articles	0.019	0.197	0.506	−0.165	−0.001
q2_8	Use frequency of video	0.053	0.008	0.598	−0.025	−0.058
q2_9	Use frequency of reservation for restaurants, travel	−0.015	0.088	0.386	0.131	0.121
q2_10	Use frequency of game	0.020	−0.030	0.289	0.209	−0.050
q2_11	Use frequency of shopping	0.020	0.176	0.550	−0.115	−0.064
q2_12	Use frequency of SNS	0.081	−0.255	0.566	0.175	−0.034
q2_13	Use frequency of information exchange with friends	−0.084	−0.030	0.656	0.030	0.079
q2_14	Use frequency of check things online	−0.086	0.086	0.564	0.021	−0.016

Table 4 (continued)

		Factor				
		PC and software use capability	Access to ICT device/PC use	Frequency of information exchange/retrieval	AI-related device use	Software use-word processors and spreadsheet
q3_1	Can you make good use of word processing software?	0.333	0.067	0.037	−0.004	0.682
q3_2	Can you make good use of spreadsheet software?	0.406	0.016	−0.043	0.034	0.687
q3_3	Can you make good use of presentation software?	0.562	−0.108	−0.087	0.164	0.360
q3_4	Can you make good use of image editing software?	0.647	−0.030	−0.120	0.175	0.015
q3_5	Can you make good use of attaching files?	0.472	0.078	0.221	−0.131	0.264
q3_6	Can you make good use of PC setting/software addition/peripheral connection?	0.826	0.042	−0.014	−0.109	0.045
q3_7	Can you make good use of Internet bank transfer?	0.682	0.043	0.088	−0.123	−0.057
q3_8	Can you make good use of online storage/cloud service?	0.879	−0.100	−0.043	0.133	−0.114
q4_1	Have you used a pet-type robot?	−0.007	0.051	−0.090	0.366	0.021
q4_2	Have you used a vacuum cleaner robot?	−0.023	0.088	−0.085	0.401	0.073
q4_3	Have you used a face-to-face humanoid robot?	−0.045	0.051	−0.019	0.392	0.043
q4_4	Have you used the merchandise recommendation function?	0.060	0.050	0.123	0.429	−0.032
q4_5	Have you used the friend introduction function on SNS?	−0.002	−0.102	0.245	0.479	0.023
q4_6	Have you used the personal assistant service function?	0.065	0.004	0.059	0.497	−0.022

Maximum likelihood method with promax rotation

KMO: 0.905

Table 5 Factor analysis of SC: factor loading

		Factor			
		Structural SC: group activities	Cognitive SC	Structural SC: contact with others	Structural SC: work-place
Factor contribution		2.423	2.443	2.606	1.289
q12_1	Frequency of contact with neighbors	0.084	−0.008	0.657	−0.048
q12_3	Frequency of contact with friends and acquaintances	−0.040	−0.022	0.632	0.144
q12_4	Frequency of contact with relatives	−0.031	0.005	0.563	0.127
q12_5	Frequency of contact with colleagues	0.057	0.003	0.117	0.552
q13_1_1	Frequency of participation in local group activities	0.786	−0.018	0.089	−0.006
q13_1_2	Frequency of participation in sports/hobby/entertaining group activities	0.358	−0.022	0.235	−0.111
q13_1_3	Frequency of participation in volunteer/NPO activities	0.853	0.014	−0.054	−0.041
q13_1_4	Frequency of participation in other groups activities	0.764	0.025	−0.142	0.121
q15_14	Generalized trust	0.033	0.532	0.188	−0.028
q15_15	Particularized reciprocity	0.012	0.909	−0.071	0.059
q15_16	Generalized reciprocity	−0.015	0.878	0.024	−0.039
	Have no one trustworthy	−0.099	0.099	0.526	−0.071

Maximum likelihood method with promax rotation

KMO:0.813

Table 6 Factor analysis of AI perception: factor loading

		Factor			
		Specific use of AI—pros and cons	Artistic use of AI and use of AI as a substitute for friends—pros and cons	Impact of AI on society	AI or human (prefer AI)
Factor contribution		6.966	5.154	3.836	4.237
q5_1	Do you think AI will make us happier?	0.300	0.065	0.363	0.070
q6_1	Do you think AI will make human relations closer/weaker?	−0.114	0.030	0.612	−0.045
q6_2	Do you think AI will enhance/control our lives?	0.106	−0.095	0.676	−0.040
q6_3	Do you think AI will make us poor/free us from hard work?	0.063	−0.094	0.764	0.004
q6_4	Do you think AI will make us accomplish more/deprive us of our creativity?	−0.016	−0.021	0.799	0.018
q6_5	Do you think AI will make our society crime free/place our society under surveillance?	−0.022	−0.011	0.678	0.009
q6_6	Do you think AI will make economic inequality decrease/increase?	−0.239	0.109	0.540	−0.039
q7_1	AI use in society in the medical scene: pros and cons	0.688	−0.006	−0.045	0.016
q7_2	AI use in society to foresee dangerous people: pros and cons	0.532	0.111	−0.063	0.000
q7_3	AI use in society for an automatic operating system: pros and cons	0.649	0.053	0.057	0.041
q7_4	AI use in society for elderly care/cooking/clean up: pros and cons	0.857	−0.125	−0.011	−0.004
q7_5	AI use in society for automatic translation: pros and cons	0.861	−0.156	−0.087	−0.068
q7_6	AI use in society for professional office work: pros and cons	0.459	0.320	0.076	0.057
q7_7	AI use in society to do creative and artistic activities: pros and cons	−0.077	0.842	−0.026	−0.016
q7_8	AI use in society to chat with friends: pros and cons	0.063	0.717	0.004	−0.001
q8_1	Will you personally use medical diagnoses by AI?	0.644	0.081	−0.010	0.055
q8_2	Will you personally use AI to foresee dangerous character in other people?	0.548	0.159	−0.042	0.003
q8_3	Will you personally use an automatic driving system?	0.599	0.128	0.070	0.024
q8_4	Will you personally use AI for elderly care/cooking/clean up?	0.813	−0.040	0.006	−0.005

Table 6 (continued)

		Factor			
		Specific use of AI—pros and cons	Artistic use of AI and use of AI as a substitute for friends—pros and cons	Impact of AI on society	AI or human (prefer AI)
q8_5	Will you personally use AI for automatic translation?	0.836	−0.114	−0.049	−0.059
q8_6	Will you personally use AI for professional work?	0.407	0.475	0.048	0.014
q8_7	Will you personally use AI for creative activities?	−0.025	0.909	−0.047	−0.059
q8_8	Will you use AI as a substitute for friends and partners?	0.054	0.774	−0.017	−0.019
q9_1	AI or human: town watch	0.170	−0.067	−0.015	0.442
q9_2	AI or human: healthcare	0.241	−0.090	−0.011	0.450
q9_3	AI or human: date planning	−0.268	0.282	0.037	0.462
q9_4	AI or human: food service	0.049	−0.019	0.039	0.561
q9_5	AI or human: HR planning	0.029	−0.078	−0.025	0.694
q9_6	AI or human: school education	−0.040	0.005	−0.006	0.727
q9_7	AI or human: policy making	−0.072	0.003	−0.072	0.685

Maximum likelihood method with promax rotations

KMO: 0.878

- 7 questions on the respondent's choice between AI or Humans in 7 applications, measured using a four-point Likert scale.

The questions on AI in our survey cover four broad areas that we call AI perception as a whole. There were also questions on the personal characteristics of the respondents including gender, age, educational attainment, marital status, occupation, form of employment (permanent or temporary), family income, number of cohabiting people, time spent in current residence, municipality, and perception of risk. The questionnaire was checked and approved by the Ethical Committee (Social Science) of Tohoku University.[3] The authors have no competing interests to declare.

3.2 Methodology

RS1 We conducted three exploratory factor analyses (EFA) using the abovementioned data on ICT literacy, SC, and perceptions of AI to obtain information on basic factors in each of the three groups of questions.

RS2 Then, using the factor scores obtained from the explanatory analyses, we performed an analysis with SEM to confirm the validity of the factors obtained by the exploratory factor analyses in light of the results of preceding studies. As an extension of the third wave of previous studies that have attempted to explain the impact of SC on ICT, we used SC factors as independent variables and ICT factors as dependent ones.

RS3 We performed another SEM to see the impact of each of the four components of SC obtained from the factor analysis on perceptions of AI.

Besides these SEM analyses, we carried out logistic regressions with dichotomized scores, categorical regressions and OLSs without dichotomizing factor scores (the results not shown in the present paper). We obtained mostly the same tendency as the results of these regressions. We used SPSS ver. 25 with AMOS ver. 26 for all analyses.

4 Results

As a result of applying EFAs using the maximum likelihood method with promax rotation, five factors concerning ICT literacy, four concerning SC, and four concerning perceptions of AI were extracted (see Tables 4, 5, and 6). As shown in Tables 4, 5, and 6, the KMO[4] scores for ICT literacy, SC, and perceptions of AI were 0.905, 0.813, and 0.878, respectively. All the factors are with eigenvalues over one except for one SC factor.

[3] Approved by the Research Ethics Committee of Tohoku University on July 11, 2018. Approval number: 0711-115252.

[4] Kaiser–Meyer–Olkin measure of sampling adequacy. The value closer to one means the higher adequacy of the sample.

The five factors related to ICT literacy were labeled "PC and software use capability" (eigenvalue = 7.591, $\alpha = 0.862$), "access to ICT devices and PC" (2.631, $\alpha = 0.742$), "frequency of information retrieval/exchange" (eigenvalue = 2.278, $\alpha = 0.751$), "AI-related device use" (eigenvalue = 1.772, $\alpha = 0.679$), and "software use—word processors and spreadsheets" (eigenvalue = 1.317, $\alpha = 0.914$), as seen in Table 4. Factors with eigenvalues equal to or over one were selected.

As seen in Table 5, we obtained four factors in relation to SC, namely "structural SC group activities" (eigenvalue = 3.895, $\alpha = 0.694$), "cognitive SC" (eigenvalue = 1.894, $\alpha = 0.830$), "structural SC—contacts with others" (eigenvalue = 1.310, $\alpha = 0.669$), and "structural SC—workplace" (eigenvalue = 0.839, $\alpha =$ na). Although the eigenvalue of the last SC factor is less than one, the factor accounts for approximately 7% of the variance. Besides, SC at the workplace is known to be of importance in many empirical studies including one by the author. We decided to include it as an SC factor.

As seen in Table 6, we obtained four factors pertaining to AI perception, namely "AI practical use—pros and cons" (eigenvalue = 8.506, $\alpha = 0.911$), "AI artistic use and as a substitute for friends" (eigenvalue = 3.477, $\alpha = 0.876$), "influence of AI on society" (eigenvalue = 2.595, $\alpha = 0.803$), and "AI or Human" (eigenvalue = 1.922, $\alpha = 0.778$).

The following analyses were carried out using the factor scores obtained from the abovementioned factor analyses. Higher values of AI-related factors indicate affirmative perceptions of AI.

Analysis one Association among SC, ICT literacy, and AI perception

As an extension of wave three, we assumed SC as an explanatory variable and ICT literacy as a dependent one. Whereas most previous studies are based on a partial picture of ICT such as email exchanges or particular types of SNSs (e.g., Facebook, Line, or RPGs), this study places greater emphasis on comprehensive literacy of ICT such as the capabilities of PC and software use.

As seen in Fig. 1, a confirmatory pass analysis was conducted using all factors on SC, ICT literacy, and AI perception obtained in the exploratory factor analyses to test the validity of the factors in explaining the associations among SC, ICT literacy, and AI perception. The three latent variables (SC, ICT literacy, AI perception) we created do not contradict with the knowledge found by preceding studies, especially those in the wave three mentioned above. That is, SC is positively associated with ICT literacy. It also provided a new finding. ICT literacy is positively associated with AI perception as well. Therefore, SC is indirectly associated with affirmative perceptions of AI.

Analysis two How each component of SC is associated with ICT literacy and AI perception?

We carried out another SEM to find out how each of the four components of SC is associated with ICT literacy and AI perception (Fig. 2).

The findings Fig. 2 suggests are as follows.

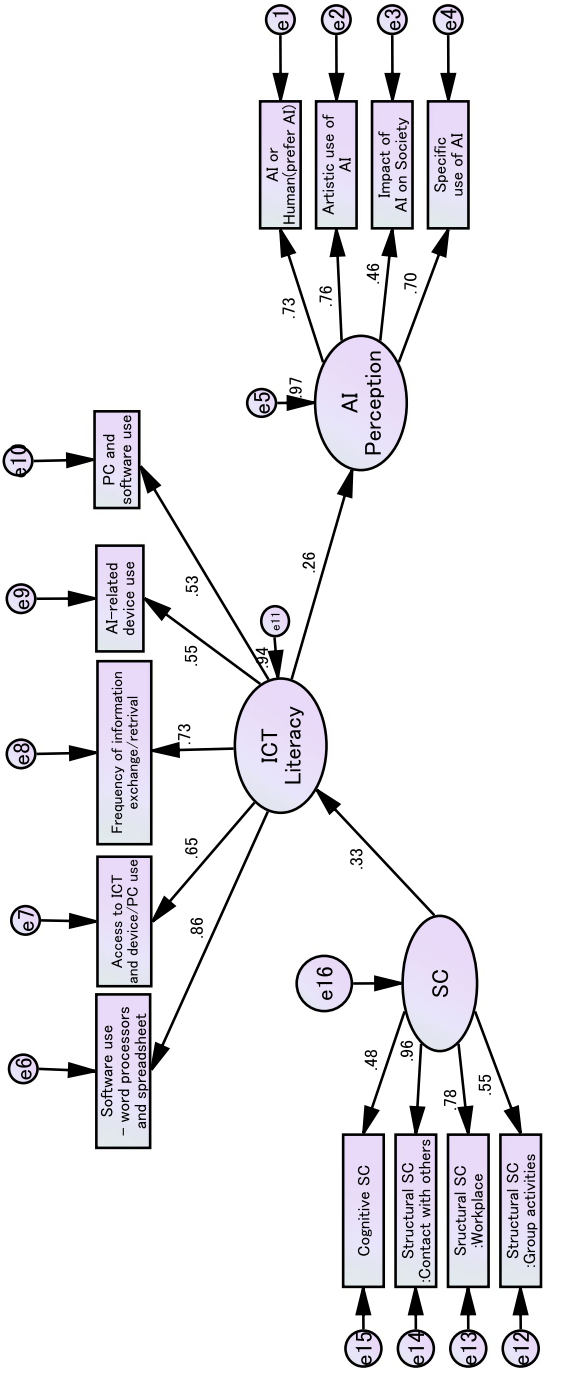


Fig. 1 A confirmatory pass analysis based on factor scores obtained from EFAs. $\chi^2 = 3012.7$, $df = 63$, $p = 0.000$; GFI = 0.907, AGFI = 0.866, RMSEA = 0.097

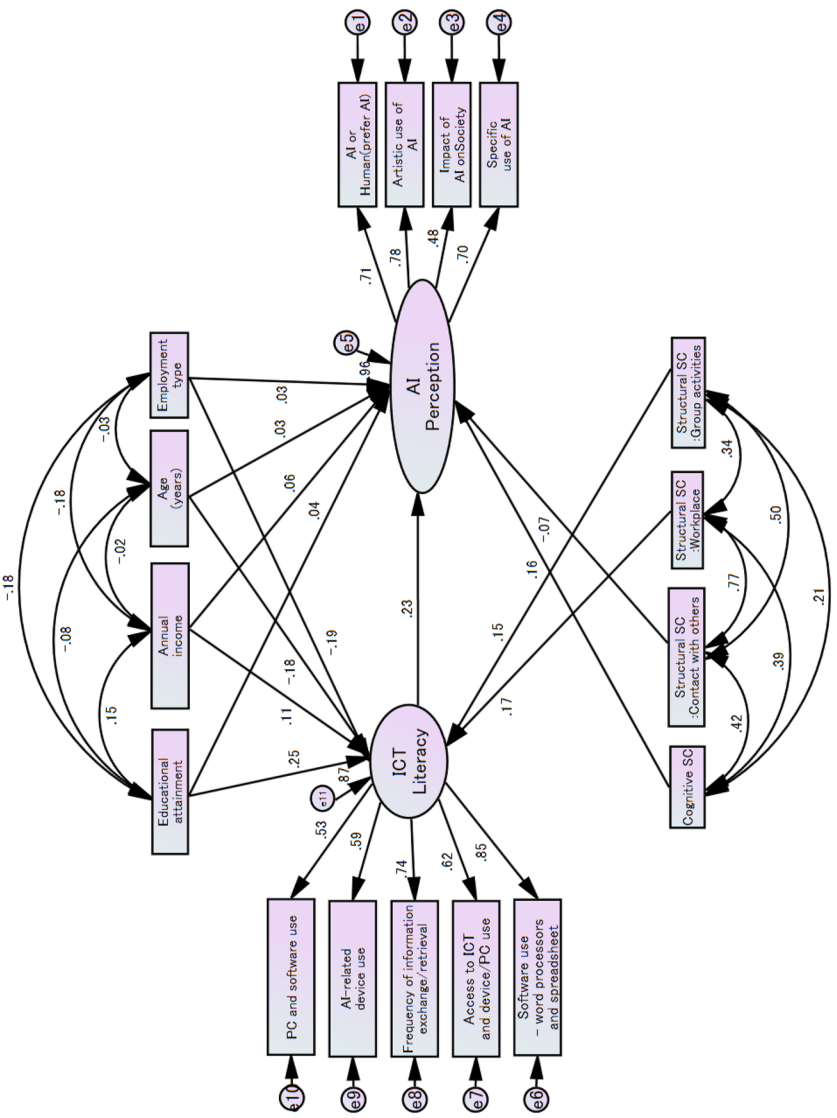


Fig. 2 How each componet of SC is associated with ICT literacy and AI perception? $\chi^2 = 4036.1$, $df = 102$, $p = 0.000$; GFI = 0.905, AGFI = 0.858, RMSEA = 0.088

1. With regard to direct association from the SC components to ICT literacy, only two elements of SC, namely "structural SC—workplace" and "structural SC—group participation" has statistically significant positive association with ICT literacy. Neither "cognitive SC" nor "structural SC—contact with others" has no association with ICT literacy.
2. Therefore, the indirect pass suggested in Figure one from ICT literacy to AI perception is assumed to be mainly caused by "structural SC—workplace" and "structural SC—group participation".
3. However, the two elements of SC ("cognitive SC" and "structural SC—contact with others") which do not have association with ICT literacy do have direct association with AI perception. One ("cognitive SC") positive, another("structural SC—contact with others") negative.
4. With regard to the attributes of respondents, both education and annual income have positive association with ICT literacy, while age and employment type have negative association with ICT literacy. Those with higher education or income show higher ICT literacy, while those aged or with more unstable jobs tend to have lower ICT literacy.
5. In summary, SC is mainly associated with affirmative perceptions of AI. However, structural SC has an ambivalent effect on AI perception: "contacts with others" represents cautious views on AI, while "group participation" and "workplace" promote affirmative perceptions of AI.

5 Discussion

5.1 Direct impact of SC on AI perception

We assume that the results of analysis two (Fig. 2) represent the direct impact of SC on AI perception. Those with a higher cognitive SC are affirmative toward AI. On the other hand, "Structural SC: contact with others" has a negative effect toward the use of AI. Although not shown in the paper, when it comes to the preference between AI and humans, those with frequent contact with others prefer humans over AI (a statistically significant negative correlation observed between "structural SC—contacts with others" and "AI perception: AI or Human"). Since "contacts with others" mainly mean daily social contacts with neighbors and with friends and acquaintances in a neighborhood, it may represent homophily or networks among people with the same background. Those with close contacts with others may have difficulties in adopting new "relationship" with AI.

5.2 Indirect impact of SC on AI perception through ICT literacy

The results of the two analyses shown in Figs. 1 and 2 combined may suggest the indirect impact of two types of structural SC, "SC—group activities" and "SC—workplace" on AI perception through ICT literacy. ICT provides an interface between AI and humans, and thus, it functions as an intermediary between SC and

AI perception. From that perspective, the strong association between structural SC and ICT literacy shown in Fig. 1 as well as the association between ICT literacy and the specific types of SC (Fig. 2) suggests the existence of an indirect pass between structural SC and AI perception. In other words, activities in various networks such as group activities and those at workplace enhance ICT literacy and, in turn, lead to affirmative perceptions of practical use of AI. The network made at workplace and by group participation may be less homophilic than networks of neighbors. In fact, they may represent networks' heterophily (Rogers 1962). The former enhances networks among those that have similar backgrounds, whereas the later fosters networks between those with different backgrounds. The results of Figs. 1 and 2 suggest heterophily embedded in networks may work for the affirmative perceptions of AI through ICT literacy.

6 Limitations

This study has a number of limitations. First, the samples used are biased. The data were collected online based on the registry of a web-survey firm. A total of 5000 answers were collected, comprising 1000 answers from each of the 10-year age groups from 20 to 69 years. The average age of the sample (44.8 years) was younger than that of the entire Japanese population at of the end of October 2017 (47.4 years[5]). Virtually, all respondents were capable of using the Internet and, thus, their ICT literacy was assumed to be higher than that of the average Japanese population. Second, we cannot specify any causality based on the cross-sectional data used in this study except for causality from SC/ICT literacy to AI perception. Longitudinal data are required to identify causality. Third, the scope of our study is limited to SC at the individual level. No contextual SC or community SC is examined. Fourth, SEMs utilized in Figs. 1 and 2 leave somewhat to be desired in terms of both the GFI and χ^2 test. Fifth, it did not mention the theoretical mechanisms that clarify the causalities among SC, ICT literacy, and AI perception. Finally, this paper did not directly address the ultimate research question on how AI will affect SC in the future.

7 Conclusion

We found a statistically significant positive association between SC and positive perceptions of AI through ITC literacy. SC is indirectly associated with AI perception by enhancing ICT literacy, and then ICT literacy enhances AI perception. This indirect effect seems to be mainly caused by two types of structural SC: SC through group participations and SC at work place.

[5] The Japanese population as of October 1, 2019, based on a Census by the Statistics Bureau of Japan. https://www.stat.go.jp/data/nihon/02.html accessed on August 25, 2019.

Besides this indirect effect, SC has direct effect on AI perception. Cognitive SC has direct positive association with AI perception, whereas structural SC in the form of contacts with others was negatively associated with AI perception.

Thus, structural SC has an ambivalent effect on AI perception. Structural SC through group participation as well as SC at work place may work for the positive perceptions of AI through ICT literacy, while those with higher level of contacts with others tend to be cautious toward AI.

Both cognitive SC and structural SC assume important roles for the smooth transition into the AI era. Policy makers should be aware of the difference in the way each of these SC forms affects AI perception. SC seems to have mainly promotional impact on the AI perception. However, the precautionary function of SC should not be put on the back burner for the sound social acceptance of AI. In any case, SC assumes an important role in the creation of AI perception.

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