The Role of Task Complexity and Personality in the Effect of Co-Presence

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Abstract

As the need for distance collaboration increases, so does the need for online social engagement. One prominent factor in the latter is the experience of co-presence, i.e. the sensation of being with others in an online environment. Social facilitation theories indicate that the presence of others influences one's speed and performance accuracy, depending on the complexity of the task and on one's personality traits. Additionally, a high self-esteem and extraversion have been shown to result in performance enhancement in contexts with co-presence, whereas a low self-esteem and neuroticism are associated with performance impairment. This study investigated whether these social facilitation theories translate to online situations with co-presence. Forty-seven participants were each assigned a Sudoku puzzle in the online collaboration tool Google Docs, where one half worked alone and the other half worked simultaneously with two other participants (each on their own puzzle), thereby experiencing co-presence. Within these two groups, one half received a simple puzzle and the other half a relatively complex puzzle. Results showed a significant difference between the two groups with the complex puzzles: the co-presence group showed significantly lower accuracy than the group that worked alone. In addition, the two co-presence groups reported that the presence of others had a negative effect on their performance (but not their speed). Otherwise, none of the tests yielded significant results in line with social facilitation theories, including any observations regarding personality.

Keywords: Co-Presence, Social Presence, Collaboration Tools, Social Facilitation, Task Complexity, Personality

The Role of Task Complexity and Personality in the Effect of Co-Presence

Since the development of Web 2.0, a large proportion of worldwide communication has moved to the Internet (Lai & Turban, 2008). Distances are dramatically reduced and collaboration can be facilitated at any place and any time. Online document collaboration tools such as Google Docs, Overleaf , and MindMeister are used to collaborate efficiently at distance. Especially during pandemics such as COVID-19, these tools are used on a large scale. However, their use offers multiple advantages outside of these extraordinary situations as well. They increase flexibility in group work, allow for more diversity in a group (Ijsselsteijn, 2004; Maznevski & Chudoba, 2000), and lower costs and carbon emission, as travelling becomes unnecessary (Ijsselsteijn, 2004; Noonan, 2008). No wonder that such tools have become increasingly popular (Vallance, Towndrow, & Wiz, 2010) and are widely used in both education (Chu & Kennedy, 2011; Koh & Lim, 2012) and the workplace (Matthews, Whittaker, Moran, & Yang, 2010).

However, the use of online collaboration tools does not guarantee effective and efficient collaboration. The lack of physical presence of the collaborators has its downsides, such as the lack of social cues and the exacerbation of social loafing (Chidambaram & Tung, 2005). Certain design elements can be implemented to increase the sense of being there with others, often referred to as co-presence (e.g., Ijsselsteijn, 2004). An example is displaying avatars of collaborators that are currently active in the document somewhere in the interface, as integrated in Google Docs for example (see Figure 1).

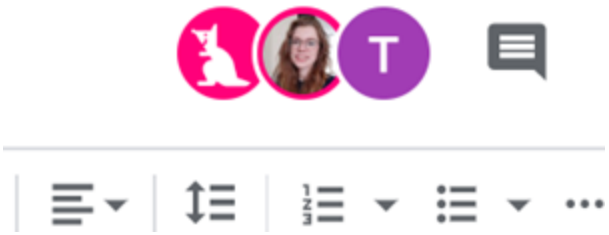


Figure 1. Co-presence: Depiction of collaborators in Google Docs.

This study investigates the effect of such co-presence-enhancing elements on users' experience and behaviour. E.g., do they indeed enhance effectiveness and efficiency in online collaboration? More specifically, this study tries to establish if there are factors that mediate the effect of co-presence (such as task complexity), as to date there is little research that relates these theories from social psychology to online environments. The findings of this study can contribute to the development of guidelines regarding adaptation and personalisation of co-presence-enhancing elements.

Related Work

Co-presence is defined as the "sense of being together in a shared space at the same time" (Ijsselsteijn, 2004, p. 136), thereby combining physical presence (i.e., feeling physically present in an environment) and social presence (feeling the "nearness" of others). The experience of co-presence primarily depends on the design of the tool or the virtual environment that is used. For instance, online co-presence can be facilitated using avatars (Blascovich et al., 2002; Slater & Steed, 2002), shared navigation and a chat function (Wei, Seedorf, Lowry, Thum, & Shulze, 2017), and by displaying actions of others in the virtual environment (Durlach & Slater, 2000).

The social presence aspect of co-presence facilitates social enhancement, where users can show support, encouragement, and acceptance (Eggins & Slade, as cited in Rafaeli & Noy, 2002). Short, Williams, and Christie (as cited in Rafaeli & Noy, 2002) even go as far as to say that evidence that others are attending is crucial in facilitating socially meaningful interaction. In

addition to social enhancement, co-presence seems to increase engagement in general. Participants stayed longer in the virtual environment as the level of virtual presence increased (Rafaeli & Noy, 2002) and an increase in co-presence was associated with an increase in curiosity, focussed attention, felt involvement, and endurability (Wei et al., 2017). Additionally, it was found that participants improved their results under conditions of higher virtual presence (Rafaeli & Noy, 2002).

A large share of the effect of co-presence can be attributed to the perception that others are watching. Social psychology theories argue that the mere presence of others results in the tendency to perform (certain) tasks better when others are present and calls this social facilitation (Rafaeli & Noy, 2002). On a physiological level, research has shown that the feeling of being watched can evoke arousal, resulting in an excited and activated state (e.g., Somerville et al., 2013). On a psychological level, the presence of others is often associated with evaluation apprehension and competition (Cottrell, as cited in Harkins, 1987). In addition, the possibility of evaluation can result in more self-awareness, leading to a greater attention to how one's performance matches some standard (Carver & Scheier, 1981). Research has shown that social facilitation also takes place in environments where social facilitators are not in close physical proximity, or when they are virtual (e.g., Park & Catrambone, 2007).

A large scale meta-analysis by Bond and Titus (1983) showed that social facilitation does not always enhance performance. They found that performance speed is increased when the task is simple, but that complex tasks are performed slower and less accurately. Zajonc (1965) explains this by stating that the presence of others enhances an individual's tendency for dominant responses. He argues that for a simple task, the dominant response is mostly correct, while for complex tasks the opposite is true. Bond (1982) has a different theory to explain the

moderating effect of task complexity. He states that individuals are motivated to project an image of competence in the presence of others. When the task is simple, individuals are likely to have a correct response to the task and thus their performance is enhanced, whilst responses to complex tasks are likely to be incorrect and result in social impairment. Again, these theories are based on situations with real (physically-present) audiences, but later research indicates that these claims also hold true for virtual environments (e.g., Aiello & Svec, 1993).

Uziel (2007) found that compared to task complexity, personality is a more substantial moderator of the effect of social presence on performance. He argued that these different reactions to social presence stem from social-affective tendencies that people have to social situations in general. A positive reaction toward social presence is reflected in traits of extraversion and high self-esteem, whereas a negative reaction toward social presence is reflected in traits of neuroticism and low self-esteem. This is in line with the Sociometer theory, which states that low self-esteem individuals may perceive others as rejecting most of the time, whilst high self-esteem individuals see others as generally accepting towards them (Leary, Tambor, Terdal, & Downs, 1995). Yet again, this theory is found to translate to the online domain, in this case by taking the level of self-efficacy as a measure for personality (Robinson-Staveley & Cooper, 1990). However, no studies regarding online situations were found which incorporated extraversion and neuroticism, let alone in combination with task complexity.

Thus, the question arises whether the findings in literature regarding social facilitation also hold true for virtual environments, and thus whether it is desirable to adapt the presence of co-presence-enhancing elements to the mediating factors found in literature. Consequently, the following research questions and hypotheses are used in this study:

RQ1: To what extent is task complexity a mediating factor in the effect of online co-presence?

H1: Online co-presence increases the speed for simple tasks (Bond & Titus, 1983).

H2: Online co-presence reduces the speed and performance accuracy for complex tasks (Bond & Titus, 1983).

RQ2: To what extent is personality a mediating factor in the effect of online co-presence?

H3: High self-esteem individuals and extraverted individuals perform better under online co-presence than when working alone (Uziel, 2007).

H4: Low self-esteem individuals and neurotic individuals perform worse under online co-presence than when working alone (Uziel, 2007).

Method

Experimental Design

The study followed a between-subjects design, in which four conditions were established based on two dimensions. The first dimension is whether the condition facilitated the experience of co-presence, i.e., whether the participant was alone or whether they found themselves in the presence of two other participants. The second dimension is the task complexity, to investigate whether having a simple or complex task has an effect on the experience and performance. Combined, these two dimensions create four conditions, as illustrated in Table 1.

Table 1. Experimental design.

		Task complexity	
		Simple	**Complex**
Co-presence?	**Individual**	Individual-Simple (IS)	Individual-Complex (IC)
	Together	Together-Simple (TS)	Together-Complex (TC)

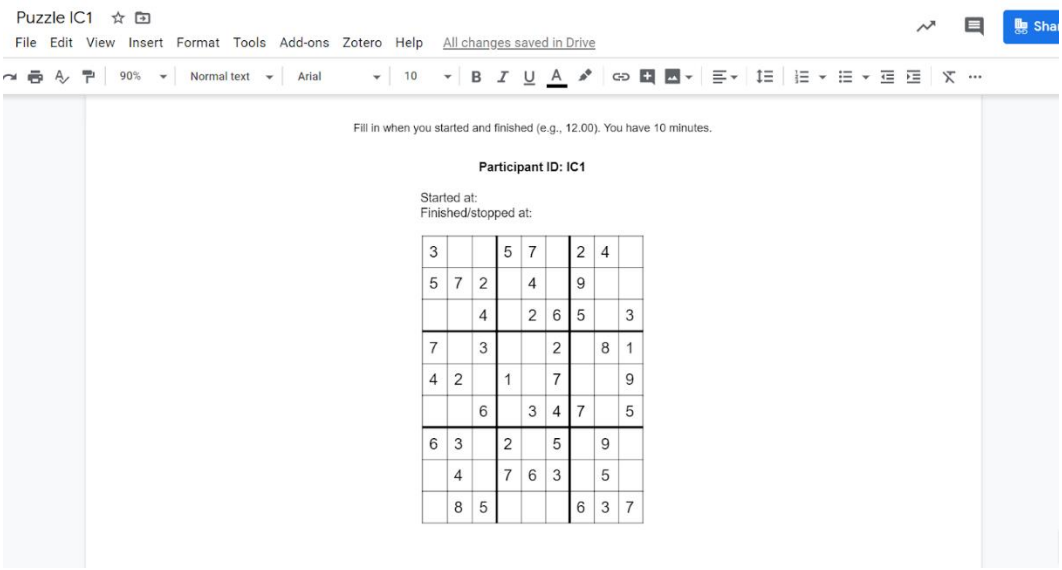
The abbreviations IS, IC, TS, and TC will be used throughout this paper to indicate the conditions. If two conditions from one dimension are indicated at once, they will be referred to as e.g. “the two Together conditions”.

Material

In all conditions, the participants were assigned a Sudoku puzzle to solve. This type of puzzle was selected because it is considered simple and because it is popular in Europe and North America (Semeniuk, as cited in Mantere & Koljonen, 2007). The difficulty of the puzzle determined the difference between the simple and complex condition. Difficult Sudoku puzzles contain less values in the start position than easy Sudoku puzzles.

The online collaboration tool Google Docs was chosen as the environment for this study, as it is well known and highly used amongst Dutch students (Pijpers, 2019). Familiarity with the tool was hypothesised to cause less distraction and therefore more awareness of the presence of others. Therefore, it was also checked beforehand if all participants were familiar with Google Docs. Another advantage was that the participants could easily log in with their personal Google account.

In the Individual conditions, the document that the participants worked in looked like Figure 2. The values that were already present in the starting position were coloured black. The empty cells were set to have light blue text, so that any value entered by the participant could be distinguished from the original values. Besides the Sudoku puzzle and the fields to fill in the start and end time, the document contained two short instructions at the top (a repetition of the most important information that was already provided beforehand) and the Participant ID already filled in below that.



3			5	7		2	4	
5	7	2		4		9		
		4		2	6	5		3
7		3			2		8	1
4	2		1		7			9
		6		3	4	7		5
6	3		2		5		9	
	4		7	6	3		5	
	8	5				6	3	7

Figure 2. Document for Individual conditions (IS&IC).

In the Together conditions the Sudoku puzzles were depicted in the same way, as well as the instructions, Participant ID, and a field to enter the start and end time. The difference was that in these conditions, three puzzles were placed directly next to each other (see Figure 3). Hence, the participants could see each other edit real-time in the same document. A number of three participants was chosen because the proportions of the layout worked out well on the average laptop screen.

As participants were logged in with their personal Google account, they were often depicted with their initial at the top right of the interface (see Figure 3). Hovering over this initial with the mouse causes the full name of the participant to pop up. Sometimes the participants were not logged in, which caused them to be depicted as an anonymous user.

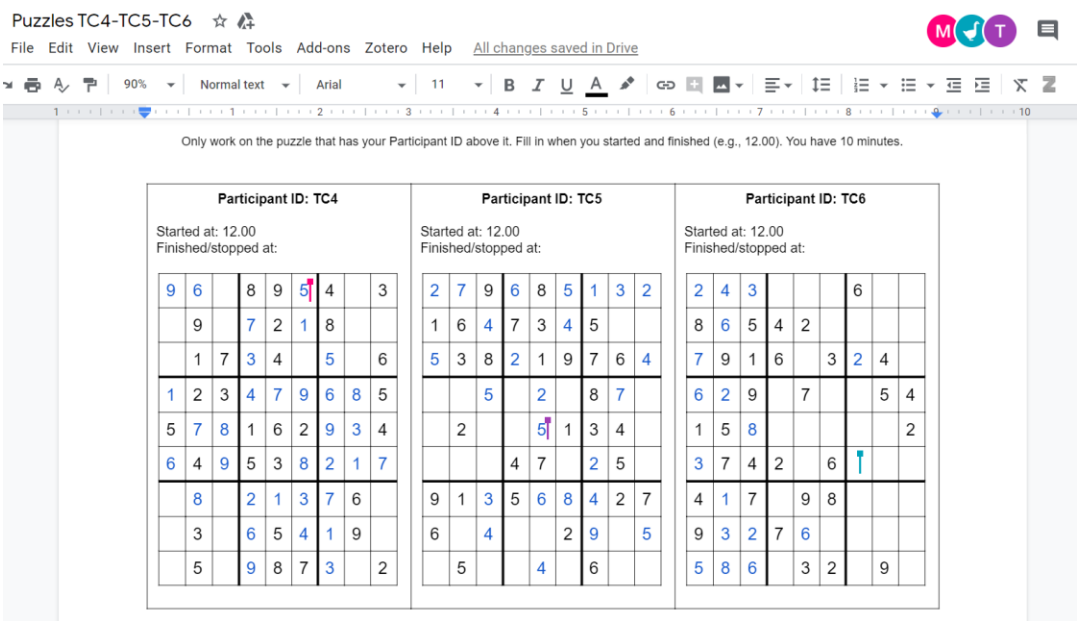


Figure 3. Document for Together conditions (TS&TC).

After working on the puzzle task in Google Docs, the participants filled in an online questionnaire to gather their demographic characteristics, their experience with Google Docs, and how they experienced the presence of others during the task (only in the Together conditions). Additionally, personality scales and co-presence scales were incorporated in this questionnaire to quantify the personality and co-presence scores.

Measurements

Participants self-reported the time spent on the Sudoku puzzle. They did this by entering the time that they started and stopped above their puzzle (see, e.g., Figure 3). Mostly, the time lapsed was 10 minutes, as this was the maximum amount of time that participants were allowed to work on the puzzle, but some participants finished early. To obtain an objective measure of speed, the number of values entered by the participant was divided by the time spent on the Sudoku puzzle, see Equation 1. This means that if a participant entered more values in 10 minutes than another participant, that the former was faster than the latter.

$$Speed = \frac{number\ of\ values}{number\ of\ minutes} \quad (1)$$

Performance accuracy was seen as the lack of incorrect values. Counting this was done by checking each puzzle against the correct, completed version.

For the performance score, speed and accuracy were combined into a single score. The intention of this combination was to penalise incorrect and slow answers, whilst rewarding correct and quick ones. For this the following calculation was used:

$$Performance = \frac{number\ of\ correct\ values}{number\ of\ minutes + number\ of\ mistakes} \quad (2)$$

As mentioned in the previous section, personality scales were included in the questionnaire to quantify personality traits for analysis. For self-esteem the widely-used Rosenberg's Self Esteem Scale (RSES; Rosenberg, 1965) was chosen. The Eysenck Personality Questionnaire Brief Version (EPQ–BV; Sato, 2005) was selected to quantify extraversion and neuroticism. Similarly, co-presence scales were used to determine to what extent the participants in the Together conditions experienced co-presence. Two different scales were selected: the one by Poeschl and Doering (2015) and the one by Kang, Choi, and Park (2007).

Participants

The sample was acquired through convenience sampling and mainly consisted of students from Utrecht University. In total, 47 persons participated in this study: 12 in each condition except for the TS condition, where one participant was not present at the arranged time[1]. The participants were placed in one of the conditions randomly and by taking their availability into account. The

[1] In this case, the researcher stood in for the missing participant (anonymously) to still have three persons present who worked on their puzzle.

researcher attempted to make groups of three (Together conditions) where the participants did not know each other, as this could have been a distracting factor. Table 2 shows participants' (demographic) data over the four conditions. The questionnaire was filled in after completing the Sudoku puzzles, so the self-report of Sudoku skills should be interpreted cautiously, especially since the difficulty of the Sudoku may have influenced these estimates too.

Table 2. Division of demographic data over the four conditions.

	IS	**TS**	**IC**	**TC**
Average age	22.0	21.5	21.1	21.2
Gender	5M, 7F	3M, 8F	2M, 10F	4M, 8F
Average Sudoku skill	5.6	4.7	4.7	3.9

Results

The outcome of the scale by Poeschl and Doering (2015; score 17.48 out of 21) was regarded as deemed high enough to conclude that participants in the Together conditions indeed experienced co-presence, as the authors did not provide interpretation guidelines for their scale. The scale by Kang et al. (2007) turned out not to be suitable for this study, as the term "(mutual) interest" might not have seemed applicable to a situation where participants worked on their Sudoku independently. This was also reflected in the fact that the first statement of this scale, "I think that other participants were aware of my presence", received a much higher average (5.52) than the rest, such as "the level of mutual interest seemed high" with an average of 3.67.

Research question 1

As stated before, RQ1 regards the effect of co-presence on speed and performance accuracy, where task difficulty is a mediating factor. An independent-samples t-test was used to compare speed in conditions with normally distributed data. A Mann-Whitney U test was used for the comparisons that dealt with non-normally distributed data. In addition, one-sample t-tests and

independent-samples t-tests were conducted to analyse how participants assessed the effect of co-presence on their speed and performance. One-sample t-tests were used for each condition to compare these assessments against the midpoint of the scale and independent-samples t-tests were used to compare these assessments between the conditions. As literature provided reason for expecting a directional relationship, all tests were one-tailed. An alpha level of .05 was used for all statistical tests in this study.

Objective Measures.

The first hypothesis was formulated as: o*nline co-presence increases the speed for simple tasks (speed TS > speed IS)*. Figure 4 illustrates the distribution of the speed of all participants, where the colours and shapes indicate to which condition they belong. As shown in this figure, in the TS condition there were both higher and lower scores than in the IS condition.

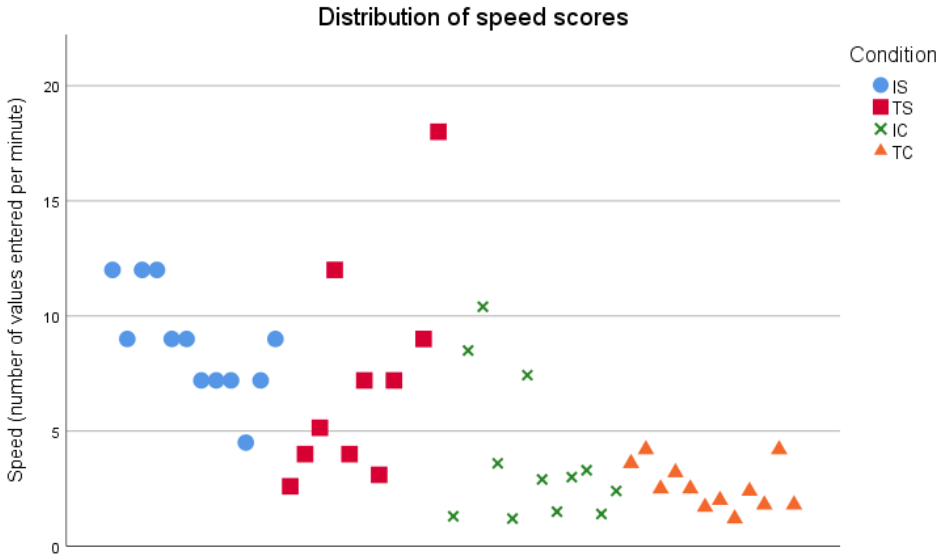


Figure 4. Distribution of all speed scores.

An independent-samples t-test was conducted to compare speed in solving simple Sudoku puzzles in conditions with co-presence (TS) and without (IS). There was no significant difference in the scores between the TS group (M = 7.22, SD = 4.78) and the IS group (M = 8.76,

SD = 2.33), $t(20) = -.995$, $p = .166$ (one-tailed). These results suggest that experiencing co-presence does not increase speed, at least not for simple puzzle tasks.

The second hypothesis was stated as: *online co-presence reduces the speed and performance accuracy for complex tasks.* For the first part of this hypothesis (*speed TC < speed IC*), Figure 4 gives reason to suspect that this hypothesis holds true, as three green crosses are clearly above all orange triangles (i.e., three participants in the IC condition were faster than any of the participants in the TC condition). However, a Mann-Whitney U test showed no evidence to support a difference between the speed of the group that experienced co-presence and the group that did not ($U = 64.5$, $N_{IC} = 12$, $N_{TC} = 12$, $p = .336$, one-tailed), despite the TC group having a lower mean rank (11.88) than the IC group (13.13).

For the second part of Hypothesis 2, *co-presence reduces the performance accuracy for complex tasks (performance accuracy TC < performance accuracy IC),* the number of mistakes made per participant was taken as the measure for performance accuracy. Figure 5 illustrates the distribution of mistakes in each of the conditions. In line with the hypothesis, it shows that more participants made (a higher number of) mistakes in the TC condition compared to the IC condition.

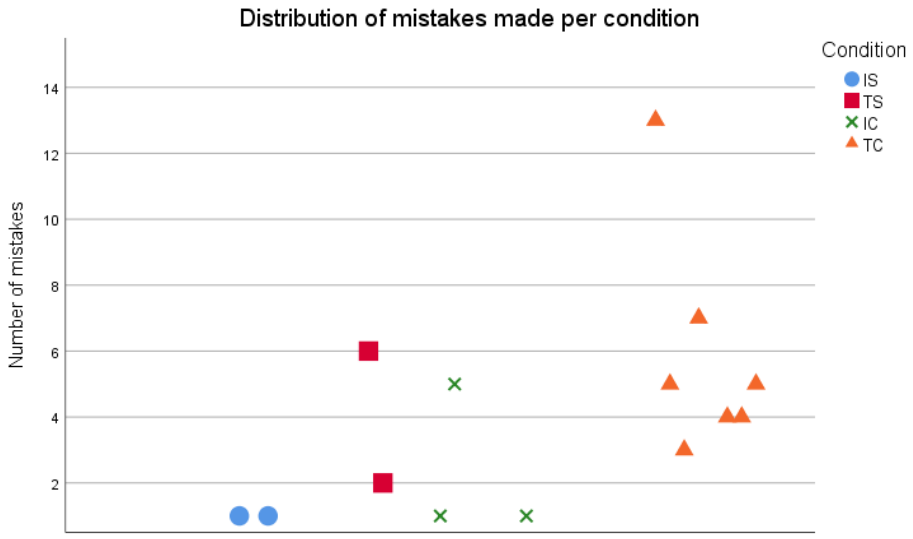


Figure 5. Number of mistakes made per condition (data points with zero mistakes excluded).

Indeed, a Mann-Whitney U test revealed a significant difference (U = 41.5, N_{IC} = 12, N_{TC} = 12, p = .039, r = 0.40, one-tailed) between the TC group (*mean rank* = 15.04) and the IC group (*mean rank* = 9.96), suggesting that co-presence impairs performance accuracy for complex tasks.

In addition to the number of mistakes, the performance scores were compared to see if performance in general diminished as well. A Mann-Whitney U test showed that the 12 participants in the TC condition (mean rank = 10) compared to the 12 participants in the IC condition (mean rank = 15) performed significantly worse in solving complex puzzles (U = 42, N_{IC} = 12, N_{TC} = 12, p = .045, r = .35, one-tailed). Thus, evidence is found suggesting a negative mediating effect of task complexity on both performance accuracy and performance in general.

Self-Reported Measures.

Besides the measured speed and performance scores, this study also looked at how participants assessed the effect of co-presence on their speed and performance. Figure 6 illustrates how participants assessed the effect of co-presence on their speed on a 7-point Likert

scale. What strikes the eye is that none of the participants in the TS condition indicated that the presence of others did not have any effect, as this would have been expressed with the score 4, the midpoint of the scale. However, a one sample t-test showed that even though the scores were dispersed, the mean score (M = 3.82, SD = 1.843) did not depart significantly from the central score 4, $t(10)$ = -.329, p = .375 (one-tailed). In other words, there was no stronger tendency towards acceleration than towards deceleration or vice versa. The TC condition showed less diversity in the ratings and the majority (5) of the participants did not feel like their speed was affected. Indeed, a one sample t-test showed no significant departure of the mean score (M = 3.67, SD = .888) from the central score 4, $t(11)$ = -1.301, p = .110 (one-tailed). Additionally, an independent-samples t-test showed no significant difference between this mean of the TC group and the mean of the TS group's self-report regarding speed, $t(21)$ = .256, p = .401 (one-tailed).

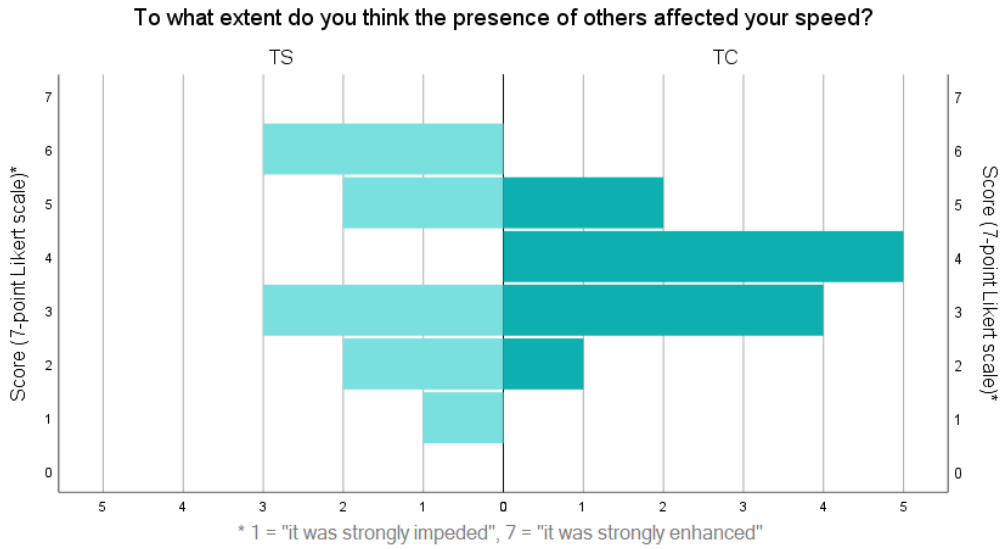


Figure 6. Participants' self-report of the effect of co-presence on speed (TS).

Participants were asked to elaborate on the selection of their ratings. In the TS condition, six participants had the idea that they were slowed down, which they attributed to being distracted by the actions of the other participants. The other five participants in this condition

thought the presence of others made them faster. Four of them spoke about experiencing a sense of competition in their elaboration, even though it was never indicated that participants competed against each other. Participants in the TC condition also elaborated on their ratings. One participant who gave a score of 4 admitted that they had zoomed in on their own puzzle, refraining themselves from seeing the others. Reasons for assuming that the presence of others had decreased speed, again included distraction, but "feeling watched" and simply stating that the "others were going faster" were also mentioned. One participant who experienced increased speed, attributed it to perceiving competition.

Figure 7 shows participants' self-report regarding the effect of co-presence on their performance. It shows that in the TC condition, only one participant experienced performance enhancement. A one sample t-test showed a significant departure of the mean score (M = 3.55, SD = .82) from the central score 4, $t(10) = -1.838$, $p = .048$ (one-tailed). Thus, similar to the outcomes of the Mann-Whitney U test on performance (accuracy), this evidence suggests that the TC group tended to experience performance impairment. Remarkably, in the TS group a one-sample t-test also showed a significant difference between the mean and the midpoint of the scale (M = 3, SD = 1), $t(10) = -3.317$, $p = .004$ (one-tailed), suggesting that participants tended to experience performance impairment in the TS condition as well. In addition, an independent-samples t-test showed no significant difference between the scores belonging to the TC group and the scores from the TS group regarding performance, $t(20) = -1.399$, $p = .089$ (one-tailed).

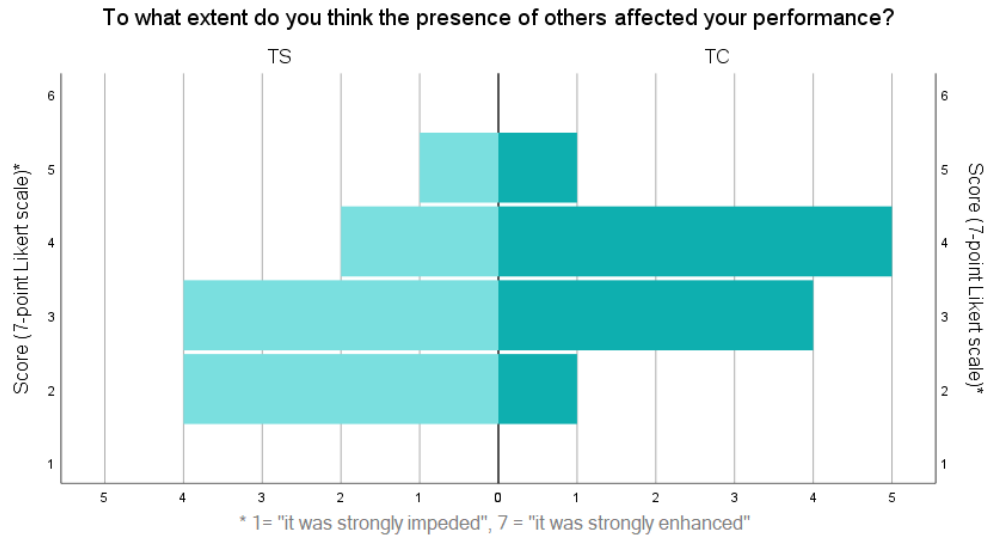


Figure 7. Participants' self-report of the effect of co-presence on performance (TC).

Again, participants were asked to explain their ratings. Six participants in the TC condition saw the presence of others as an impediment to their performance, mentioning reasons such as being distracted (1x), but also simply "feeling looked at" (2x). Five participants stated that they did not feel that their performance was affected: three of them mentioned that they just focused on their own puzzle. The only participant in this condition who felt that their performance was enhanced, mentioned experiencing a sense of competition. Participants in the TS condition gave similar reasons for the effect on their performance as the participants in the TC condition, although more participants mentioned distraction (5x). Additionally, a remarkable comment made by one participant was that they saw a causal link between their perceived pressure to work faster and the higher number of mistakes that they made.

Research Question 2

Whereas RQ1 addresses the role of task complexity on speed and performance, RQ2 regards the role of personality in performance under co-presence. Hypothesis 3 was formulated as: *high self-esteem individuals and extraverted individuals perform better under online co-presence than*

when working alone (performance TS+TC > performance IS+IC). Hypothesis 4 was stated as: *low self-esteem individuals and neurotic individuals perform worse under online co-presence than when working alone (performance TS+TC < performance IS+IC).* Thus, personality was measured in three dimensions: self-esteem, extraversion, and neuroticism. These dimensions were each explored in relation to performance to see whether personality mediates the effect of co-presence on performance. Due to the limited sample size, the use of categories (e.g., low self-esteem – high self-esteem) was not deemed desirable for analysis, as this would have resulted in scarcity in participants in certain personality categories. Moreover, it would mean that scores around the centre of the scale would be assigned to another category than a score nearby that is just beyond the centreline (Smith, 2016).

Hypothesis 3 and 4 both address the (hypothesised) mediating effect of self-esteem. Combining these two hypotheses, it is supposed that the higher the self-esteem, the better the performance under co-presence. The relationship between self-esteem and performance in the IS and TS condition is shown in Figure 8. The position of the darker dots (TS) is expected to show a positive (linear) relationship. This clearly does not seem the case and besides, the high self-esteem individuals in the Individual condition (IS) seemed to generally perform better than the high self-esteem individuals in the Together condition (TS), whilst the opposite would be expected. A similar plot for the IC and TC conditions was also not in line with the two hypotheses. Therefore, there was not sufficient reason to perform further statistical tests to see if there was a positive correlation between self-esteem and performance with regards to co-presence. Similar conclusions were drawn regarding the neuroticism and extraversion scores in combination with performance.

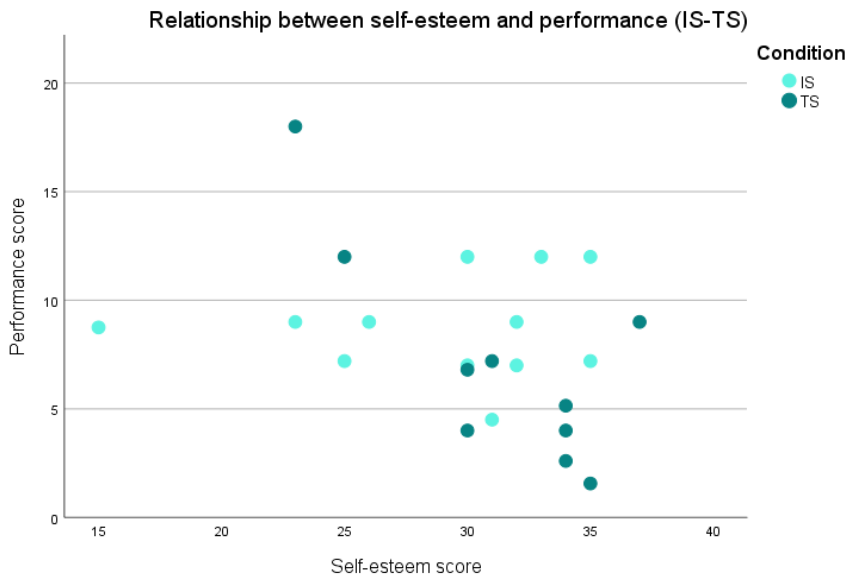


Figure 8. Scatter plot with self-esteem and performance scores (IS&TS).

Besides the measured performance scores, self-reports were collected to see whether participants felt as if the presence of others had affected their performance. Self-esteem, extraversion, and neuroticism were plotted against these self-report scores (see Figure 9). As these scores are expressed on a 7-point Likert scale, the score 4 would indicate no effect on performance, which is illustrated with a fat, horizontal line. Figure 9 shows a trend that can be considered in line with Hypothesis 4: participants with high levels of neuroticism mostly felt that their performance was impaired. However, computing Spearman's *rho* correlation coefficient showed no significant positive association between neuroticism and perspective on performance enhancement or impairment, $r(22) = -.196$, $p = .191$ (one-tailed).

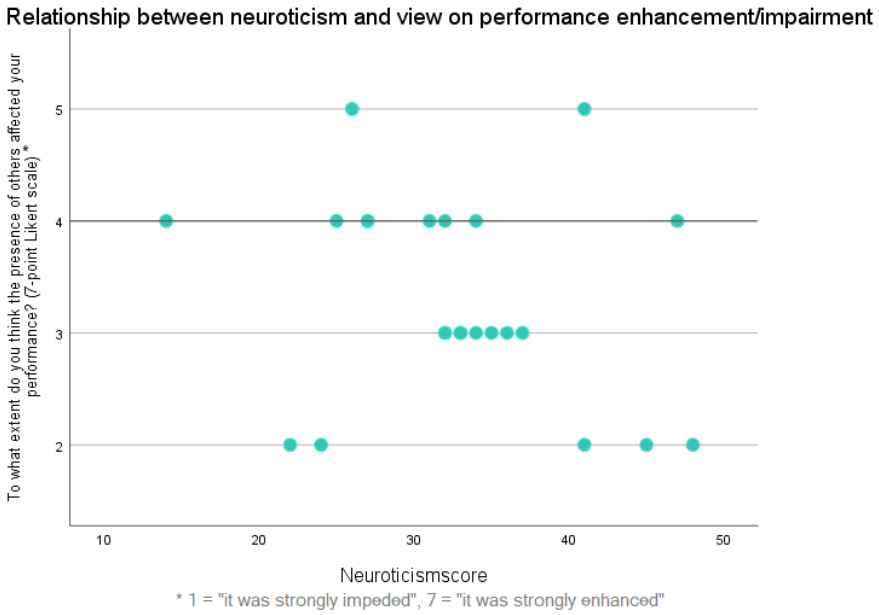


Figure 9. Relationship between neuroticism and perspective on performance enhancement/impairment.

Conclusion

This study investigated to what extent the social facilitation theories regarding task complexity and personality apply to online co-presence. Returning to RQ1, *to what extent is task complexity a mediating factor in the effect of online co-presence?*, the results indicated that task complexity did not fully mediate the effect of co-presence. There was no evidence that online co-presence increases the speed for simple or complex tasks, but this might be because co-presence affects people differently, with some becoming faster and some becoming slower. However, the TC group made significantly more mistakes than the IC group, implicating that co-presence significantly reduces performance accuracy. In all conditions, experiencing competition was seen as a factor that increased speed and performance, whereas being distracted by the progress of others was often mentioned as a factor that decreased speed and performance. There was a significant tendency towards reporting a negative effect on performance (and not on speed) by

participants in both the TS and TC condition. No evidence was found for the hypotheses belonging to RQ2, *to what extent is personality a mediating factor in the effect of online co-presence?*, mainly due to the dispersed nature of personality data. However, neurotic participants showed a trend towards associating the presence of others with performance impairment.

Discussion

This study is in the first place an enrichment of available literature on co-presence in online collaboration tools. As existing literature mostly focuses on the combination of social presence and collaboration in learning environments, this study broadens this view to see how the mere online presence of others affects performance in general. The inclusion of task complexity and personality as mediators of the effect of co-presence makes this a unique contribution to the field of social facilitation as well, as its theories are originally based on "offline" situations.

This study suggests that it is better to minimise the sense of online co-presence for complex tasks, as these tasks are associated with a decline in performance accuracy. A practical implication for designers of collaboration tools would therefore be to hide the sight of others when the task is complex. Preferably the user should be able to do this themselves, as this is also advantageous for personal preferences. Another option is to determine the task complexity automatically, but this requires technology that can detect this accurately. A recommendation for similar experiments would be to pay extra attention to the complexity of the task provided to participants and align it with the purpose of the study.

This study has its limitations, starting with this study's sample, which was limited to 47 participants. Especially when using personality as an independent variable, the sample size has to be large to cover the spectrum of each personality trait (i.e., having a sufficient number of both

e.g. highly introverted and highly extraverted participants; Smith, 2016). Another limitation regarding the sample is that the majority (at least 26 participants) participated in the Information Science Bachelor's programme or a subsequent Master's programme at Utrecht University. On the one hand, it is beneficial that this group of students is used to collaborating in online documents and is therefore a representative group. However, a wider variety of participants would still be preferred for the generalisability of the results of this study. Using Google Docs as the environment for this experiment also comes with its limitations. There was no way to enforce consistency in how the participants were displayed in the document (i.e., with their initials, a profile picture, or anonymously), which could have affected the experience of co-presence. Moreover, it can be questioned whether solving Sudoku puzzles is a representative task for using the Google Docs environment, especially since the participants were puzzling simultaneously without helping each other. One could thus argue that this was not a "collaboration situation". Moreover, the task required no use of Google Docs' collaboration functionalities, for instance the chat function or the use of comments. Choosing Sudoku puzzles as the task for the experiment has its benefits, for instance that speed and performance accuracy are easily determined and that puzzling is generally seen as fun. However, it also comes with its limitations, the most important being the difference in skill. Of course, these individual differences partially disappear when only group means are compared. But although the speed scores of each condition were normally distributed, the same cannot be said about performance scores and the number of mistakes. Although this is partly due to the skewed nature of the mistakes data (i.e., most participants made no mistakes), these differences are preferably avoided by choosing a task in which participants are (more or less) equally skilled. Finally, there are also limitations regarding the way the measurements were established. By letting participants enter

their start time and end time, this measure is both prone to impreciseness and subjectivity. The impreciseness can be overcome by integrating a timer in the environment next time, but for now this was practically not feasible as Google Docs did not allow for it.

This study showed no direct motive for personality-based personalisation, at least not for the three traits that were included in this study (self-esteem, extraversion, and neuroticism). However, the answers to the open questions did indicate that people have different reactions to co-presence, so this could still be a relevant subject for future research. In addition, quantitative measures would not have revealed that for instance a large share of the participants in the Together conditions experienced a sense of competition. Therefore, incorporating interviews in future research might provide fruitful (new) insights. It might also be interesting to compare the effect of co-presence between working individually and collaborating. In this study collaboration was excluded on purpose, as the difference between the individual conditions and Together conditions was based on whether co-presence was experienced or not, not the difference between puzzling individually or together. However, simultaneous collaboration is a prominent feature in online collaboration document tools, so including simultaneous collaboration would be a relevant approach as well.

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