

# Exploring the mutually reinforcing relationship between theory of mind and reading in adult readers

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**Background:** Research with children shows that theory of mind predicts reading comprehension both concurrently and longitudinally, while research with adults shows increased print-exposure relates to theory of mind understanding. However, until now whether reading and theory of mind have a mutually reinforcing relationship in which they promote one another in parallel has not been explored. Therefore, this study aims to explore further the relationship between theory of mind and reading by investigating reading comprehension, print-exposure and theory of mind together. **Method:** Theory of mind (Reading the Eyes in the Mind test), reading comprehension (subset of the York Adult Assessment Battery-Revised) and print-exposure (Authors Recognition Test) were measured in a sample of U.K. adults ( $N = 220$ ).

**Results:** Findings showed that theory of mind was significantly related to both reading comprehension and reading print-exposure. Further, mediation analysis showed that this relationship does not operate with theory of mind mediating the relationship between print-exposure and reading comprehension as an indirect effect of print-exposure on reading comprehension through theory of mind was not found after controlling for age, income and education.

**Conclusions:** The findings provide some initial evidence that, at least in adulthood, reading and theory of mind have a mutually reinforcing relationship in which they promote one another in parallel, but this relationship cannot be explained by theory of mind mediating the relationship between print-exposure and reading comprehension.

**Keywords:** adult literacy, print-exposure, reading comprehension, theory of mind

## Highlights

### *What is already known about this topic*

- Research with children shows that theory of mind predicts reading comprehension both concurrently and longitudinally.
- Research with adults shows increased print-exposure relates to theory of mind understanding.

### *What this paper adds*

- This paper investigated if the relationship between reading comprehension and theory of mind continues into adulthood.

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- Further, it explored if the relationship between theory of mind and reading is mutually reinforcing in that the two skills assist one another in parallel.

*Implications for theory, policy or practice*

- Findings show the relationship between reading comprehension and theory of mind continue into adulthood highlighting the robust nature of this relationship.

Reading comprehension is a complex and multifaceted skill requiring much more than basic decoding and semantic processing (Scarborough, 2001). To take meaning from a passage, a reader must go beyond the text. For example, to gain a deep interpretation, a reader of fiction must take the viewpoint of a character and monitor this prescriptive to understand the character's mental state. Research has identified many skills that may help with this process including prior background knowledge (e.g. Elbro & Buch-Iversen, 2013), vocabulary (e.g. Ouellette, 2006), grammatical understanding (e.g. Brimo et al., 2017), working memory (e.g. Cain et al., 2004), inference making (e.g. Cain & Oakhill, 1999) and motivation (e.g. Guthrie et al., 2007). Yet there is still much unknown about the process of reading comprehension, and it is possible that other skills beyond the ones already known by researchers are important. Fully understanding the reading process is vital because evidence shows that worldwide and across education systems, there are high numbers of children shown to perform at or below proficient levels on standardised reading assessments (Schleicher, 2019). This trend continues into adulthood. In England, 16.4% of adults have literacy levels considered to be 'very poor' (Sabatini, 2015), while in the United States, 19% of adults have literacy skills considered to be 'very poor' (Sabatini, 2015).

To address the above, recent developmental research has begun to explore the role that theory of mind may play in children's reading comprehension (e.g. Atkinson et al., 2017; Ebert, 2020; Kim, 2020). Indeed, a review by Dore et al. (2018) suggested that theory of mind might be the hidden factor in reading comprehension. Theory of mind is the ability to attribute mental states (such as beliefs, desires and emotions) to oneself and others (Premack & Woodruff, 1978). This capability begins to develop at around the age of 4 years old (Wimmer & Perner, 1983) and allows one to explain others' behaviour based on the understanding of their mental states (Premack & Woodruff, 1978). Theory of mind continues to develop throughout childhood (Miller, 2009), and into adulthood, individual differences can still be seen, with some adults possessing a more advanced theory of mind than others (Apperly et al., 2009). Given that all works of fiction, from preschool picture books to advanced adult novels centre around characters, their complex social situations, and their mental states (Zunshine, 2019), having a strong theory of mind could help a reader to better understand the social information within text. Moreover, even works of non-fiction include interpersonal information (Zunshine, 2019) which theory of mind may assist with. This can be explained by Kintsch's Construction Integration Model (1988) that suggests a successful comprehender must create a mental representation of the text's meaning. This mental representation may include information about characters' intentions, the author's intentions and other interpersonal information

(Graesser et al., 1994), and therefore, theory of mind could be an important source of information.

In support of this, developmental researchers have found that within a model of reading, which controls for other language and cognitive skills known to be important for reading comprehension, theory of mind can predict fiction reading comprehension in early childhood (aged 6–8 years; Kim, 2017, 2020). Moreover, longitudinal work shows theory of mind predicted reading comprehension (of one fiction and one non-fiction passage) up to 2 years later in both early childhood (Atkinson et al., 2017) and adolescence (Ebert, 2020) over the effects of other variables. Yet Dore et al. (2018) argued that more work is required to fully understand this relationship. One such avenue of further research is with adults. Adult research is important because if the relationship is found to continue into adulthood, this provides evidence that the relationship between the two skills is robust.

To date, adult research has taken a different approach compared with developmental research, as it has explored the relationship from the reverse perspective. Instead of suggesting theory of mind helps reading comprehension, research with adults suggests that reading promotes a better theory of mind, that is, that those who read more possess a more advanced theory of mind. For example, Mar et al. (2006) found that lifetime exposure to fiction (as measured by an Author Recognition Task) positively related to theory of mind as well as empathy and social ability. These findings have been replicated many times (e.g. Fong et al., 2013; Mar et al., 2009), with stronger relationships found with exposure to fiction genres that include character-driven narratives such as romance stories (Fong et al., 2013), and interestingly, no such relationship found between exposure to non-fiction books (Mar et al., 2006). Mar and Oatley (2008) conclude that reading fiction heavy in character-driven narratives provides readers with a simulated experience of social interactions leading to improvement in theory of mind. In support of this notion, experimental studies have found that reading fiction results in an immediate improvement in theory of mind. For example, Kidd and Castano (2013) demonstrated that reading segments of fiction immediately improved performance on the Reading the Mind in the Eyes Test, an advanced theory of mind test.

Taking the studies with children and the research with adults together, there is strong evidence that there is a relationship between theory of mind and reading throughout the lifespan. However, what is unclear is the direction of this relationship and if it changes with time. It is possible that the relationship between theory of mind and reading is mutually reinforcing in that across the life span at all ages the two skills continue to augment one another in parallel and in the same way. Alternatively, it is possible that the nature of the relationship changes across time. Perhaps, initially in childhood, theory of mind promotes reading comprehension, and then later in development, once a reader is competent, theory of mind no longer helps reading comprehension ability but instead large amounts of reading, especially text rich in social information, improve theory of mind understanding. Shedding some further light on the nature of this relationship in adulthood was a key aim of this study. It is important to note that both the research with children and adults has predominantly focused on fiction reading comprehension and exposure to fiction print rather than non-fiction reading (e.g. Kim, 2020; Mar et al., 2006). This is possibly because it seems more likely that theory of mind and fiction reading are related, as we would expect to see more social information within character-driven narratives (Dore et al., 2018). This said, non-fiction texts do often include interpersonal information (Zunshine, 2019), for

example history books, self-help books and biographies, in which these texts would both allow a reader to improve their theory of mind via simulation, and/or a more advanced theory of mind could lead to better understanding of the content. Moreover, as theory of mind is a metacognitive skill and other metacognitive skills are shown to be helpful for reading comprehension (refer to Baker & Beall, 2014), there is a suggestion that theory of mind may assist with reading comprehension by helping with the understanding of not only social information but also other information not necessarily related to characters or interpersonal information (refer to Atkinson et al., 2017). Therefore, the current study aimed to understand if non-fiction reading comprehension related to theory of mind.

### *The present study*

This study aimed to understand better the relationship between reading and theory of mind by bridging developmental research with children (e.g. Atkinson et al., 2017; Kim, 2020) with work with adults (e.g. Mar et al., 2006) by exploring reading comprehension as well as print-exposure in adults. Despite evidence that increased reading-exposure and theory of mind are related in adults; to date, no research has explored adults' reading comprehension ability and theory of mind together as they have with children. Studying these skills together will help to further understand the nature and robustness of the relationship between reading and theory of mind. If theory of mind is related to both reading comprehension and print-exposure in adults, this is consistent with the idea that reading and theory of mind may have a mutually reinforcing relationship throughout the life span and would be the first study to show that reading comprehension is related to theory of mind in adults in the same way that reading-exposure is. On the other hand, if reading comprehension ability is not related to theory of mind, but print-exposure is, this will suggest that the relationship is not mutually reinforcing and that the relationship is different in adulthood than reported in childhood by previous studies (e.g. Atkinson et al., 2017; Ebert, 2020; Kim, 2020). Further to the above, if the relationship is mutually reinforcing, it is possible that concurrently this relationship operates with theory of mind mediating the relation between print-exposure and reading comprehension. It is perhaps the case that more reading leads to improvements in theory of mind understanding through the process of simulation (Mar & Oatley, 2008), and then better theory of mind understanding leads to better comprehension of text.

To address the above, this study measured theory of mind, reading comprehension and print-exposure in a group of U.K. adults. Importantly, the current study measured non-fiction reading comprehension to assess if a relationship can still be found with theory of mind. The study assessed the following research questions:

- 1 Do both print-exposure and reading comprehension relate to theory of mind in adults, therefore suggesting a mutually reinforcing relationship between reading and theory of mind?
- 2 Is the nature of the above that theory of mind mediates the relationship between print-exposure and reading comprehension?

It should be noted that to fully determine if the relationship between theory of mind and reading changes across development, longitudinal data would be required. However, this study aimed to act as a preliminary investigation into how the relationship operates in adulthood and is the first to explore both reading comprehension and reading-exposure in relation to theory of mind in an adult population.

## Method

### *Participants*

A total of 220 participants (209 identified as female, 10 as male, and 1 as non-binary) ranging in age from 18 to 66 years ( $M = 40.49$  years,  $SD = 13.04$ ) took part in the study. Participants lived in the United Kingdom and were recruited either from a U.K. university, or via social media advertisements. Participants received no payment for participation, although those recruited through the university received participation points. The majority reported English as their first language ( $n = 213$ ). Of the seven who reported English to be their second language, four reported that as an adult they speak and read around 50% in English and 50% in their other language, and the remaining three reported to predominately now speak and read in English. Participants were well educated with 73.5% reporting to have at least an undergraduate degree. Further 92.7% of participants stated that they enjoyed reading for pleasure.

### *Measures*

*Theory of mind.* The Reading the Mind in the Eyes Test (RMET) revised version was used to measure theory of mind (Baron-Cohen et al., 2001). The RMET is a test of mentalising, which presents participants with 36 sets of still pictures of actors' eye regions and asks them to identify the actors' mental state from four possible options (e.g. 'Jealous', 'Panicked', 'Arrogant' and 'Hateful'). The RMET is considered an advanced theory of mind test as participants are required to put themselves into the mind of the person pictured and attribute a mental state to them (Vellante et al., 2013). Participants received one point for each correct item with a higher score suggesting a more advanced theory of mind.

*Reading comprehension.* The reading comprehension subset of the York Adult Assessment Battery-Revised (YAA-R; Warmington et al., 2013) was used to assess reading comprehension. Participants were asked to read a non-fiction passage (containing 492 words) concerning the history of chocolate. After reading the passage, participants then answered 15 comprehension questions that were scored in line with the original scoring of Warmington et al. (2013). Participants could refer to the passage throughout. Although the passage is non-fiction, it includes some social information, and participants are specifically required to reflect on this social information in three of the comprehension questions. For example, in the comprehension question: "How do you think Columbus felt about the King and Queen's reaction?" The test was initially designed to be used on undergraduate students to gauge their language skills but has since been used by research with other populations (e.g. Dash et al., 2019; Sjoblom et al., 2016).

*Print-exposure.* A fiction Author Recognition Test (ART) was used to assess print-exposure. The ART asked participants to check from a list of names those that they recognise as authors. Guessing is discouraged as participants were informed that some items were foils. Although not a direct measure of the authors the participants have read (they only need to recognise the name and not claim to have read the authors' books), the ART serves as an adequate measure of exposure to print while mitigating

social-desirability bias (Stanovich & West, 1989). The list used here (Appendix A) contained 40 real authors and 40 foils and was based on the ART used by Puglisi et al. (2017) but was updated in line with The Guardian's list of the bestselling fiction books of 2019 (Jordan, 2019) and Amazon's current best sellers at the time the research took place (Amazon, 2020). Total score was computed by taking away the number of foils checked from the number of real authors checked; therefore, a higher score indicates more print-exposure. In addition to the ART, participants were asked to report if they enjoyed reading for pleasure.

*Demographic questions.* Participants were asked their date of birth, their highest education level and their household income. Educational level was assessed on a 5-point scale: 0 (*no formal qualifications*), 1 (*GCSEs or equivalent*), 2 (*A levels, GNVQs or equivalent*), 3 (*undergraduate degree*), 4 (*postgraduate degree*) or 5 (*doctorate*). Household income was assessed on a 6-point scale: 1 (*less than £15,000*), 2 (*£15,000–£24,999*), 3 (*£25,000–£34,999*), 4 (*£35,000–£49,999*), 5 (*£50,000–£69,999*) or 6 (*£70,000 or more*).

### *Procedure*

Ethical approval for the study was granted by the University of Derby research ethics committee (ETH1920-3540). Participation took place online. After informed consent, participants completed the demographic questions and were asked to report if they enjoyed reading for pleasure. Participant then took part in each of the four measures (RMET, EQ, YAA-R and the ART) in a counterbalanced order. For the RMET, participants saw each set of eyes separately and responses were presented as multiple choice. For the YAA-R, participants saw each comprehension question separately and responded to the question by typing freely into a box with the passage always available to look back at. There was no time limit, and participants could take as long as they required with all measures.

### *Data analysis*

Only participants who took part in the full online session were included in the final analysis with all partial responses permanently deleted. Pearson's correlations were carried out to assess relationships between all measures and demographic information. Then mediation analysis was carried out to assess if theory of mind mediated the relationship between print-exposure and reading comprehension using Hayes method (Hayes, 2017). Lastly, to test if theory of mind is particularly important for understanding the social elements during reading, further analysis was carried out to assess if there was a stronger relationship between RMET and YAA-R when only the social specific questions of the YAA-R were considered.

## **Results**

Table 1 shows descriptive statistics for all measures including skewness and kurtosis values. As demonstrated by these skewness and kurtosis values, all measures were normally distributed. Table 2 shows Pearson's correlations between all measures and

**Table 1.** Descriptive statistics for all measures

Measure	Mean	SD	Range	Max	Skew	Kurtosis
RMET	27.70	3.76	15–35	36	−0.78	0.81
YAA-R	10.80	2.41	1–15	15	−0.99	1.76
ART	19.67	9.81	1–37	40	−0.15	−1.00
Age	40.49	13.04	18.5–66.4	–	0.05	−1.02
Income	3.91	1.64	1–6	6	−0.34	−1.09
Education	3.06	0.89	1–5	5	−0.42	−0.62

ART, Author Recognition Test; RMET, Reading the Mind in the Eyes Test; YAA-R, York Adult Assessment Battery-Revised.

Note: Income assessed on 6-point scale and education assessed on a 5-point scale.

**Table 2.** Correlations between all measures and demographic variables

	1	2	3	4	5	6	7
1. RMET	–	–	–	–	–	–	–
2. YAA-R	.23**	–	–	–	–	–	–
3. ART	.22**	.27**	–	–	–	–	–
4. Reading enjoyment	.17*	.17*	.34**	–	–	–	–
5. Age	.09	.15*	.59**	.19*	–	–	–
6. Income	.15*	.17*	.18*	.12	.22**	–	–
7. Education	.10	.13	.12	.10	.23**	.36**	–

Note: Reading enjoyment = participants report on if they enjoyed reading for pleasure.

ART, Author Recognition Test; RMET, Reading the Mind in the Eyes Test; YAA-R, York Adult Assessment Battery-Revised.

\*  $p < .05$ ,

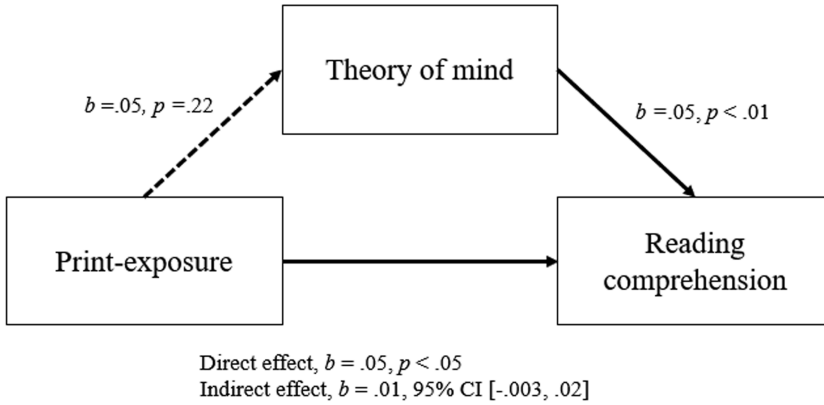
\*\*  $p < .001$ .

demographic variables. Importantly, both print-exposure (ART) and reading comprehension (YAA-R) were significantly related to theory of mind (RMET).

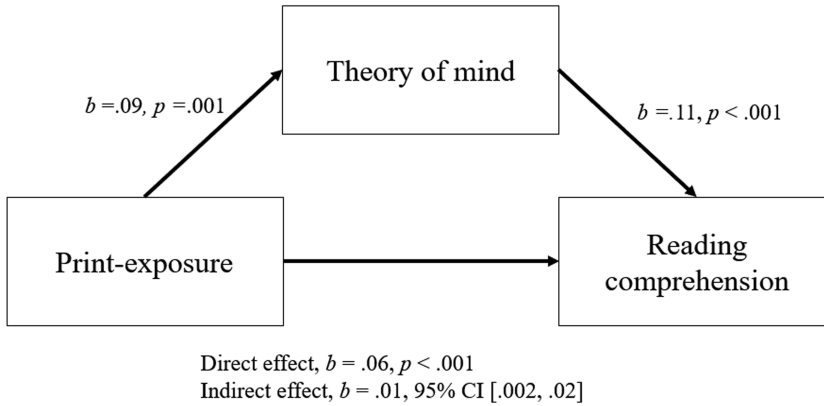
To examine the unique relations between theory of mind (RMET) and both reading comprehension (YAA-R) and reading-exposure (ART), partial correlations controlling for either ART or YAA-R were run. The relationship between RMET and YAA-R held when controlling for ART ( $r = .18$ ,  $p = .01$ ), as did the relationship between RMET and ART when controlling for YAA-R ( $r = .17$ ,  $p = .01$ ).

To test if theory of mind would mediate the relationship between print-exposure and reading comprehension, mediation using 95% confidence intervals with bootstrapping based on 1,000 samples was run. As shown in Figure 1, analysis revealed a significant indirect effect of print-exposure on reading comprehension via theory of mind,  $b = .01$ , CI [0.002, 0.02]. A significant direct effect of print-exposure on reading comprehension was also shown,  $b = .06$ ,  $p < .001$ .

To test if these relationships held when age, income and education were controlled for the mediation analysis was run again (refer to Figure 2). In this analysis, print-exposure was modelled as a predictor of reading comprehension, mediated by theory of mind and



**Figure 1.** Mediation analysis showing a direct, and indirect, effect of print-exposure on reading comprehension via theory of mind. *Note:* Full lines denote significant paths. Dotted lines denote non-significant paths. Print-exposure measured by ART, reading comprehension by YAA-R and theory of mind by RMET.



**Figure 2.** Mediation analysis showing a direct, but not and indirect, effect of print-exposure on reading comprehension via theory of mind after controlling for age, education and income. *Note:* Full lines denote significant paths. Dotted lines denote non-significant paths. Print-exposure measured by ART, reading comprehension by YAA-R and theory of mind by RMET.

age, education and income were controlled for. In this analysis, an indirect effect of print-exposure on reading comprehension via theory of mind was not found,  $b = .01$ , CI  $[-0.003, 0.02]$ , but a direct significant effect of print-exposure on reading comprehension was shown,  $b = .05, p < .05$ .

*Further analysis*

To test if theory of mind is particularly important for understanding the social elements of text, an additional Pearson’s correlation was run between theory of mind (RMET) and a reading comprehension score that only included the three questions from the YAA-R that specifically asked about social information, to assess if the relationship would be stronger. This relationship was shown to be very similar in strength to the



relationship between RMET and full YAA-R scores (both  $r = .23, p < .001$ ). Further, partial correlations showed that this significant relationship between the three social question and RMET score held when controlling for age, income and education ( $r = .22, p < .01$ ).

## Discussion

This study aimed to understand further the relationship between reading and theory of mind in adults. In doing this, the study addresses the call by Dore et al. (2018) for more research in this area. The study aimed to assess the relation theory of mind has with both reading comprehension and print-exposure to determine if theory of mind has a mutually reinforcing relationship with reading in that reading more (increased print-exposure) improves theory of mind, while at the same time having an advanced theory of mind leads to improved reading comprehension skills. The study hypothesised that this would be the case and that more specifically theory of mind would be able to explain (or mediate) the relationship between print-exposure and reading comprehension. Results showed that theory of mind was related to both reading comprehension and to print-exposure (even when controlling for the other) thus providing some preliminary evidence that the relationship between theory of mind and reading is mutually reinforcing in adults. Further, mediation analysis showed that print-exposure both directly, and indirectly via theory of mind, predicted reading comprehension explaining a small amount of variance. However, this relationship did not hold when age, education and household income were controlled for.

The finding that print-exposure relates to theory mind supports previous research (e.g. Fong et al., 2013; Mar et al., 2006, 2009), which suggested that increased reading of fiction promotes a more advanced theory of mind. This could be because reading fiction provides a reader with an opportunity to simulate social interactions leading to improvements in theory of mind. On the other hand, the finding that theory of mind relates to reading comprehension is a novel finding within an adult population because, as far as the author is aware, this is the first research to explore these skills together in this population. This finding could suggest that a more advanced theory of mind promotes better competency in comprehending passages of text perhaps because a more advanced theory of mind helps a reader to understand the social information within text and create a more advanced mental model of what the passage is about (Kintsch, 1988). However, it should be noted that this study was correlation in nature and therefore the direction of this relationship cannot be determined. This finding supports and extends developmental research with children, which has shown that theory of mind promotes reading comprehension both concurrently (Kim, 2020) as well as across time (Atkinson et al., 2017; Ebert, 2020) in young children and adolescents. This study provides the first evidence that this relationship continues into adulthood.

Taken together, the findings provide some preliminary evidence that the relationship between theory of mind and reading is mutually reinforcing. Dore et al. (2018) hypothesise that the relationship between theory of mind and reading could function in one of two ways. Either, first in childhood theory of mind promotes reading comprehension and then later in adulthood, once a reader is competent, large amounts of reading improves theory of mind. Or, the relationship is mutually reinforcing in that across the life span the two skills continue to assist one another in the same way. The current findings provide preliminary

evidence to support the second suggestion, although further research including longitudinal work is required to determine if the relationship operates in the same way in children and throughout the lifespan. However, given that research with children shows both that theory of mind promotes better reading comprehension (Atkinson et al., 2017; Ebert, 2020) and that exposure to narrative rich media predicts children's theory of mind ability aged 4 to 6 years (Mar et al., 2010), this lifespan bidirectional relationship appears likely. It should be noted although that there is an alternative explanation, instead it could be that those who have an advanced theory of mind may just enjoy reading, especially about social relationships.

To further understand how this relationship operates, mediation analysis was conducted with theory of mind as a mediator of print-exposure and reading comprehension. This was to explore if more reading leads to improvements in theory of mind understanding through the process of simulation (Mar & Oatley, 2008), which in turns leads to better comprehension of text. Although initial mediation analysis found this to be the case, when age, income and education were controlled for, the path between print-exposure and theory of mind became insignificant. These findings perhaps suggest that the relationship theory of mind has to reading comprehension is stronger than that between theory of mind and print-exposure, as this path still held. Perhaps suggesting that, at least in adults, the assistance of theory of mind is more important for reading comprehension ability than the assistance print-exposure gives to theory of mind ability. Thus, suggesting that the relationship might not be entirely equally mutually reinforcing.

### *Limitations and future directions*

Although these findings provide some initial evidence that reading and theory of mind have a mutually reinforcing relationship, there are several points to consider when interpreting the findings. Firstly, there may be issues in the generalisability of findings in terms of gender and print-exposure. The sample comprised 95% female participants, and 92.7% of participants stated that they enjoyed reading for pleasure. In terms of gender, this may be an issue given that research with children consistently indicates better performance on theory of mind tasks (Calero et al., 2013) and tests of reading comprehension (Logan & Johnston, 2010) in girls. However, this said, adult research generally finds limited evidence for gender differences in reading comprehension ability (Hannon, 2014; Oda & Abdul-Khadim, 2017). In terms of print-exposure, given that almost all the sample identified themselves as 'readers', it is possible that the relationships found here may not replicated in 'non-readers'. Because of the voluntary nature of research participation, biased samples (including gender imbalances) are an issue that exist in the field of psychology in general (Dickinson et al., 2012; Nielsen et al., 2017), and this issue is in no means limited to this study, but future research should aim to replicate this study with an emphasis on obtaining a more representative sample in terms of gender and print-exposure.

It should also be noted that in the present investigation, participants read a non-fiction passage to measure reading comprehension, whereas they identified the names of fiction authors as a proxy of print-exposure. The YAA-R was chosen as the measure of reading comprehension for two reasons. Firstly, there is some, although limited, evidence to suggest that theory of mind assists with non-fiction as well as fiction reading comprehension

(refer to Atkinson et al., 2017) and so one of the aims of this study was to explore this further and in an adult population. Secondly, there are limited standardised measures of reading comprehension for adults, and the YAA-R is well used in research (e.g. Dash et al., 2019; Sjoblom et al., 2016). The YAA-R passage used here did include some social information and three of the 15 comprehension questions required participants to reflect on this social information. When only the sum of these social comprehension questions was included in the correlation analysis, the relationship strength was similar to that of the relationship between the full YAA-R score and theory of mind, suggesting that theory of mind perhaps assists comprehension in further ways beyond understanding social information. This is something supported by Florit et al. (2020), who found theory of mind related to reading comprehension of non-fiction texts in children aged 10. If theory of mind relates more strongly to both fiction versus non-fiction reading comprehension and print-exposure should be explored further by comparing the relationships using both a fiction and non-fiction measure of reading comprehension and a fiction and non-fiction measure of print-exposure.

There are several variables that could affect the relationships between reading comprehension and print-exposure to theory of mind that the current study did not control for. These include intelligence, reading fluency and vocabulary. Research consistently shows a strong relationship between reading comprehension and intelligence in both adults (Mellard et al., 2010) and children (Johann et al., 2020), and intelligence is shown to relate to print-exposure (Mol & Bus, 2011). Moreover, as a key part of the reading process (Klauda & Guthrie, 2008), a participant's reading fluency ability would have contributed to their reading comprehension ability. Future research may therefore wish to replicate this study controlling for these variables to assess if the relationships still hold. In addition, given that vocabulary is shown to have a strong relationship with both theory of mind (Milligan et al., 2007) and reading comprehension (Ouellette, 2006), the effects of vocabulary on this relationship need to be considered by future studies.

### *Conclusion*

This study provides initial evidence that reading and theory of mind have a mutually reinforcing relationship, at least in adulthood. The study suggests that in parallel, an advanced theory of mind may help with the understanding of a passage of text leading to better comprehension, and more print-exposure may provide more experience of advanced social situations leading to a more advanced theory of mind. Mediation analysis suggests that this relationship does not operate with theory of mind mediating the relationship between print-exposure and reading comprehension and that the relationship between theory of mind and reading comprehension is perhaps stronger than that between theory of mind and print-exposure. Further research is required to determine if this mutual relationship operates the same way in children and, if so, explore the educational implications for the literacy classroom. Moreover, future research should investigate more explicitly if the relationships are the same for non-fiction and fiction reading. This will assist with understanding why and how reading and social understanding promote one another.

### Acknowledgement

The author would like to thank the participants for their time.

### Conflict of interest

No potential conflict of interest was reported by the author.

### Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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## Appendix A

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Ian McEwan*	Nicky Wellfair	Gemma Hymas
Mark Bentley	Stephen King*	Beth Motley
Madeline Whitaker	Matthew Dyke	Dan Brown*
Danielle Steel*	Andrew Voss	Dan Marcal
Sebastien Lauzier	James Gambold	Zadie Smith*
Lee Child*	Margaret Atwood*	David Abbott
Matthew Brindley	Tayari Jones*	Barnaby Pitts
Dean Koontz*	Ann Patchett*	Jemma Read
Candice Carty-Williams*	Guy Warner	Heather Morris*
Caroline Crockett	Bernardine Evaristo*	James Patterson*

Adrian Fendall	Maggie O'Farrell*	Pat Barker*
Jeffery Archer*	Tom Guy	Lynette Webster
Joseph Roberts	Florence Chamberlain	Monica Crowther
Bernard Cornwell*	George Orwell*	Jackie Collins*
Jessica Rushton.	Celeste Ng*	Richard Murphy
Caroline Tee	Piers Brazier	Helen Fielding*
Cecilia Ahern*	Jodi Picoult*	Nick Hornby*
Sally Rooney*	Duncan Normington	Tracey Payton
Lisa Jewell*	Martina Cole*	Colin Stokes
George Savidge	E. L. James*	John Grisham*
Ian Rankin*	Vicki Williams	Kate Atkinson*
Georgina Holmes	Sophie Zadeh	Stuart Baugh
Eleanor Talbot	Stieg Larsson*	Doris Lessing
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*Received 10 March 2021; revised version received 7 February 2022.*

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