A preliminary investigation on the performance of brain-injured witnesses on target-absent line-up procedures.

Charlotte Gibert[a] & Dara Mojtahedi [b]*

[ab] International Research Centre for Investigative Psychology, Department of Psychology, School of Human and Health Sciences, University of Huddersfield, UK

** Requests for reprints should be addressed to Dara Mojtahedi, Department of Psychology, School of Human and Health Sciences, University of Huddersfield, Queensgate, Huddersfield HD1 3DH, UK*

E-mail: d.mojtahedi@hud.ac.uk

Telephone: +44 (0)1484 471311

Ethical standards

Declaration of conflicts of interest
Author A [Charlotte Gibbert] has declared no conflicts of interest
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Ethical approval
All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee (add as appropriate) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent
Informed consent was obtained from all individual participants included in the study

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The current study was a preliminary investigation that aimed to compare the performance of eyewitnesses with and without a brain injury on two target-absent line-up procedures: a simultaneous procedure and a sequential procedure with confidence ratings. Fifteen participants with mild to moderate brain injury (eleven male) were recruited through their local Headway branches. Ten non-brain injured participants (six male) were also recruited. A 2x2 design was employed and both brain-injured and non-brain injured participants were randomly assigned to either the simultaneous or sequential line-up condition. Both conditions were shown a short video of a non-violent crime taking place before then being shown a target-absent photograph line-up. Measures of general cognitive ability and general memory recall were also included. A multi-nominal logistical regression found that brain injured witnesses were no more statistically likely to make a false identification regardless of line-up procedure. It was also found that participants with a greater memory ability were in fact more likely to make a false identification. Implications discussed include the need for more education and training for police and jurors regarding the ability of brain injured witnesses to provide reliable testimonies and a need to express caution regarding the tendency to believe more confident eyewitnesses when they have a brain injury.

Introduction

Line-up identification

Within many investigations where the police have identified a potential suspect, a photographic line-up (otherwise known as an identification parade) is used to determine whether an eyewitness can identify the correct suspect to the crime (Behrman & Davey, 2001). Typically, a photo of the suspect is placed among the photos of multiple innocent people who are unrelated to the crime (*foils*); subsequently, the witness is asked if they can identify the suspect from the line-up (Doob & Kirshenbaum, 1973; Malpass & Devine). Both police officers and jurors rely heavily on the identification of witnesses to provide sufficient evidence for convicting the alleged suspect (Loftus, 1996; Semmler, Brewer & Douglas, 2011; Sporer, 1993). Notwithstanding this, research has consistently shown that eyewitnesses can often be inaccurate and thus, such reports may not always be a reliable form of legal evidence (Behrman & Davey, 2001; Brewer & Palmer, 2010; Brewer & Wells, 2011; Mojtahedi, Ioannou, Hammond, 2017; Pozzulo & Lindsay; 1998). This is partially due to most witnesses tending to believe that the perpetrator is present within the line-up (Memon, Hope, & Gabbert, 2002). By holding this presumption, many witnesses will be motivated to make an identification, even if the target is not present within the line-up (Davies, 1996). Wells (1984, 1993) maintained that the traditional line-up approach favoured relative judgement i.e. the witness will evaluate individuals on the basis of how much they resemble what they recall of the suspect, with the one having the greatest likeness being positively identified.

Despite the wealth of research on eyewitness line-up identification, there is relatively little research investigating the complexities of eyewitness identification for witnesses with brain injuries — with many researchers overlooking the applications of alternative line-up identification procedures in improving the performance accuracy of brain-injured witnesses. Approximately 348,934 individuals within the UK acquire a brain injury each year (Headway, 2015). The consequent effects of severe brain damage are wide ranging but most commonly involve significant deterioration of an individual's memory, visual-perceptual skills and information processing abilities (Christodoulou et al., 2001; Headway, 2017a; Mathias & Wheaton, 2007; Warren, 1993). Due to the consequent vulnerabilities of individuals with such deficits, it is not uncommon for them to fall victim to interpersonal crimes such as domestic abuse (Hiday, Swartz, Swanson, Borum, & Wagner, 1999; Mantell, 2010). It is therefore important to consider how people with such difficulties can be best supported when they are required to engage with police procedures such as an eyewitness identification line-up, both in terms of caring for the vulnerable individual and ensuring that accurate evidence is gathered against guilty parties.

Brain injury and memory

There is a wide range of literature evidencing the effect of brain injury on types of memory function (e.g. Crowell & Curtiss, 2010; Levin, 1990; Shum, Harris & O'Gorman, 2014; Vanderploeg, Crowell & Curtiss, 2001; Wammes, Good & Fernandes, 2017). Various studies have found that individuals with a brain injury have a distinct cognitive profile compared to those who do not, specifically characterised by deficits in autobiographical and episodic memory (Wammes et al., 2017). Research has also found that individuals with a history of traumatic brain injury are likely to learn at a significantly lower rate and more likely to make false-positive errors on visual memory tasks, in comparison to non-brain injured individuals (Schum et al., 2014). The implications from such findings would suggest that witnesses with traumatic brain injuries would be more susceptible to misidentifying an innocent individual during a line-up identification task. Other research has looked at the effect of brain injury on facial recognition (e.g. Babbage et al. 2011; Knox & Douglas, 2009; McDonald, 2005; Yin, 1970). In a meta-analysis of 13 studies, Babbage et al. (2011) found that individuals with a history of traumatic brain injury performed significantly less accurately than controls on facial recognition tasks.

Brain injury and line-up identification

Currently, there is limited empirical research specifically looking at how individuals with brain injuries perform in various eyewitness line-up situations. A limited number of studies have been conducted however, into the utility or effectiveness of line-up identification methods with witnesses who have cognitive impairments resulting from circumstances such as intellectual disability (e.g. Wilcock & Henry, 2013) and developmental disorders (e.g. Norheim & Ferraro, 2016). Ericson and Isaacs (2013) compared the line-up identification accuracy rate between participants with and without intellectual disabilities. The study found that despite both groups making the same amount of correct identification, participants with intellectual disabilities were more likely to make a false identification and were also more prone to guessing. Similarly, Wilcock and Henry (2013) found that witness with intellectual disabilities performed poorer in both a target-present and target-absent photographic line-up and were more likely to make a false identification in both conditions. Interestingly, Wilcock and Henry (2013) also found that witnesses with intellectual disability were more confident in their decisions although there was no positive correlation between accuracy and confidence suggesting that those with intellectual disability lacked insight into their cognitive deficits related to recall accuracy.

As a result of the possible cognitive deficits in memory recall, facial recognition and general intellectual ability that brain injury victims can sustain, there is a risk that they may not be seen as reliable eyewitnesses by jurors and police officials (Stobbs & Kebbell, 2003). Studies that have looked at public perceptions of brain injury have found that biases exist regarding behaviour and cognitive ability among the general public. For example, Linden and Crothers (2006) found, in a survey of members of the public, that negative views regarding the possibility of confusion and unpredictability in brain injured individuals are common. Studies on police attitudes indicate that officers are more likely to perceive elderly witnesses as being unreliable and incompetent in comparison to their relatively younger counterparts (Kwong See, Hoffman & Wood, 1998; Wright & Holiday, 2005). Although the aforementioned studies looked at elderly witnesses rather than witnesses with acquired brain injuries, Yarmey (2000) highlighted that these negative perceptions were due to the commonly held belief that elderly individuals possess poor memory recall abilities. Thus, it can be suggested that if police officers and jurors are likely to associate an acquired brain injury with poor memory recall, they may be more likely to perceive brain-injured witnesses as being unreliable sources of evidence — a bias perception which could lead to statements or evidence given by witnesses with brain injuries being discounted, leading to guilty suspects being free to reoffend.

Despite the majority consensus of the previous literature, some research has suggested that witnesses with cognitive impairments could still perform similarly to the general population in line-up identification tasks. Ternes and Yuille (2008) found that witnesses with cognitive disabilities were no worse at identifying a perpetrator from a photographic line-up than controls when interviewed in a non-leading manner. Thus, it may be that further research is needed in order to clarify the ability of individuals with various cognitive deficits to be reliable witnesses and what accommodations are required in order to allow such witnesses to engage effectively in the identification process. As a result, the present study was interested in determining if an alternative line-up identification procedure could allow brain-injured witnesses to perform more accurately.

Alternative Line-up identification procedures.

In order to reduce the likelihood of a false identification being made, several changes to line-up procedures have been proposed and studied. Lindsay and Wells (1985) examined the utility of presenting line-up members sequentially (one at a time) rather than simultaneously (all at once) and found that this method reduced the likelihood of a false identification without any corresponding reduction in correct identifications. This phenomenon came to be known as the sequential superiority effect support for which has been found in several meta-analytic studies (Steblay, Dystart, Fulero and Lindsay, 2001; Steblay, Dysart & Wells, 2011).

In addition to sequential line-up procedures, several studies have also looked at confidence ratings as an alternative to more traditional line-up identification techniques (Brewer, Weber, Wooton & Lindsay, 2012; Sauer, Brewer & Weber 2008; Sauer et al., 2008). Such approaches involve witnesses giving a rating (e.g. from 0-100%) on how confident they are that each individual in the line-up is the correct suspect as opposed to either providing a single positive identification or rejecting the line-up as a whole. In order to classify a rating as a positive or negative identification Brewer et al. (2012) looked at whether participants had given a single maximum confidence value across the line-up (one rating that was higher than all the others). The absence of a single maximum rating was considered to be “no selection”. Positive selections were then separated depending on whether they referred to a suspect or a foil. The confidence value for each suspect that was classified as an identification was calculated by looking at the maximum value across all participants that discriminated accurate from inaccurate decisions. For example, if a maximum value of 80% confidence led to the highest number of correct identifications across all participants 80% was set as the criterion for which an identification was considered to have been made for that suspect. Confidence ratings allow assessments to be made regarding how much a certain individual in the line-up is favoured over others and the extent to which each individual matches the witnesses’ memory, something not possible with a single binary decision. Research has demonstrated the effectiveness of the confidence-rating approach, with multiple studies indicating that confidence ratings produced 24% to 66% higher decision accuracy than the more traditional line up procedure (Brewer et al., 2012; Sauer et al., 2008). Building upon existing research, Sauer et al. (2012) employed classification algorithms to determine whether a confidence rating given indicated a positive or negative identification of a suspect. It was found that confidence rating procedures were more accurate at producing correct identifications than single yes/no decisions across various stimuli. It has been suggested that one reason confidence ratings have been found to produce higher accuracy in line-up situations as participants do not feel as pressured to make a choice therefore leading to a reduced likelihood of a false identification (Sauer et al., 2008). As discussed previously, research has suggested that the high level of eyewitness misidentification amongst eyewitnesses with intellectual disabilities may be due to the individuals being more prone to guessing (Ericson & Isaacs, 2013). Thus, the confidence-rating approach to line-up procedures may help reduce the inaccuracy of brain-injured witnesses. However, to date, no existing research study has attempted to observe the effectiveness of this approach on brain-injured witnesses.

Current study

To date, very little research has investigated the reliability of eyewitnesses with brain injury and — to the researchers’ knowledge — no study has attempted to observe the effectiveness of different line-up identification procedures on eliciting accurate responses from eyewitnesses with brain injuries. The present study hoped to provide a starting point for research in this area to begin investigating the different interventions for improving the reliability of eyewitness evidence from such individuals.

The present study aimed to compare the performance of individuals with mild to moderate acquired brain injuries to controls (non-brain injured participants) in two target-absent line-up procedures: a traditional simultaneous procedure requiring a binary "yes/no" answer and a sequential procedure using confidence ratings. The present study also aimed to compare the utility of the two line-up conditions with brain injured witnesses in reducing the likelihood of false identifications. Based on the existing literature surrounding the effectiveness of different line-up techniques in the general population and in those with cognitive impairments the following hypotheses were made:

1. That brain injured participants will perform less well than non-brain injured participants on measures of general memory and cognitive ability.
2. Participants with a brain injury will be more likely to make a false identification than the control group across the two line-up conditions.
3. Brain injured participants in the confidence rating condition will be less likely to make a false identification than brain injured participants in the traditional line-up condition.

Methods

Participants

Due to the vulnerability of individuals with brain-injuries, the present study was conducted on a relatively small sample size. The study initially recruited 28 participants, however, three of the participants with brain injuries were excluded from the study as they were not able to give informed consent or in one instance, had a history of trauma related to police involvement after an assault. Consequently, the study was conducted on 25 participants (eight females and seventeen males). The mode age range of participants was between 36 and 50 (SD= 1.11). Of the 25 participants, a total of 15 (11 male and 4 female) were diagnosed with mild to moderate brain injury. In terms of the types of brain injury disclosed by participants; eight had a traumatic brain injury (TBI), three had experienced a haemorrhage, one encephalitis, one a stroke and two "other". The length of time since these participants had acquired their brain injuries ranged between 5-20 years. Participants were recruited through their local Headway organisation. Headway is a national charity providing support and rehabilitation services to individuals who have suffered any form of head injury (Headway.org.uk, 2017c). Ten non-brain-injured participants (six males and four females) were also recruited and randomly assigned to one of the two line-up conditions in order for comparisons to be made between the two groups.

Design

The current study employed a 2x2 design whereby both brain-injured and non-brain-injured participants were recruited and randomly allocated to one of two conditions: Traditional line-up or confidence ratings. The independent variables (IV) were the different line-up conditions (traditional and confidence rating) and brain injury (present/not-present) and the dependant variable (DV) was whether a false identification of a suspect was made or not. In the confidence ratings condition, participants were asked to indicate how confident they were about each suspect being the trespasser from the footage, on a scale of one to five (1= Not at all Confident; 2= Not Very Confident; 3= Not Sure; 4= Somewhat Confident; 5= Very Confident). An identification was considered to have been made if the participant had given a confidence rating of four or five (somewhat confident or very confident). The study also measured each participant's general memory accuracy (see Table 1 for questions) and cognitive ability (using MoCA; see below) to determine whether the participants with brain-injuries had any cognitive impairments.

Materials

Video footage

The study used a video footage —used in Wells, Orson and Charman (2003) — to expose the participants to a criminal incident. The incident seen in the 43 second video clip is from the perspective of a person who enters an office environment and sees through a window, a man (approximately 15 feet away) on a rooftop. The footage focusses on the man's face, subsequently, the man appears to realise that he is being watched and runs off to the viewers' left. The video then goes on to view the man running through a door from the rooftop, past the camera and down a flight of stairs. The man viewed in the video can be described as a white male in his early twenties with short, dark hair. He is referred to as the trespasser in the current study.

Line-up

The study used a target-absent line-up which contained an array of six photographs, all of whom fit the general description of a young white man but none of whom were the trespasser (*foils*). The photographs were either displayed all together in a 3x2 formation (for traditional line-up condition) or sequentially (for confidence rating condition) depending on the condition. The photographs were stills taken from the line-up video used in Wells et al. (2003) and were all printed as 5.71cm by 7.61cm squares.

Cognitive Assessment

The Montreal Cognitive Assessment (MoCA) was used to provide a broad measure of participant's cognitive ability. The MoCA is a brief cognitive screening tool originally developed to aid in the detection of mild cognitive impairment (Nasreddine et al., 2005). The MoCA was selected specifically as it is straightforward and quick to administer (approximately 10 minutes) and because it can provide a broad assessment of gross cognitive strengths and weaknesses. The assessment is comprised of eight subsections (visuospatial/executive, naming, memory, attention, language, abstraction, delayed recall and orientation) that combine to give a total score out of 30. A score of 26 or less is considered abnormal. An extra point is awarded for individuals with less than 12 years education. The MoCA has been found to have good internal consistency (Chronbach's alpha of 0.83) and test-retest reliability (0.92), as reported by Nasreddine et al. (2005).

General memory assessment

Participants were also asked some general open ended and yes/no memory questions about the video clip in order to control for general memory accuracy. Table 1 details the additional questions asked.

Table 1

Additional memory questions

Question	Answer Options
What colour was the trespasser's shirt in the video?	Open answer or "Don't Know"
What colour were the trespasser's trousers in	Open answer or "Don't Know"

the video?	
In what direction did the trespasser run after being seen through the window?	"Right", "Left", "Don't Know"
Was the trespassers T shirt plain or did it have any logos/shapes?	Open answer or "Don't Know"
Was there a computer in the office?	"Yes", "No", "Don't Know"
Was it night or day outside?	"Night", "Day", "Don't Know"

Procedure

Participants were individually asked to watch the video clip on a standard laptop screen measuring 12.3 inches. All participants were then individually asked standardised questions from the MoCA in the same order. The MoCA task also fulfilled the role of a filler tasks with participants being allocated 15 minutes it (all participants were able to complete the task within this time). Participants in the traditional line up condition were shown all six suspects photographs at the same time in a 3x2 formation and were asked if they could identify the trespasser from the video clip within the line-up. Participants in this condition also had the option to choose none of the suspects if they were uncertain or unable to identify the offender from the line-up. The participants in the confidence rating condition were shown each of the six photographs sequentially and were asked to make a rating for each as to how confident they were that that particular suspect was the trespasser viewed in the video clip previously, using a 5-point likert scale (1 = Not at all confident and 5 = Very confident). There was no time limit given in either condition. This was because it was felt that providing a strict time limit on answering the questions would add further cognitive load onto the task which may influence the accuracy of the results taken from as well as increasing the pressure felt by brain injured participants.

Participants were then asked a series of additional general memory questions about the event seen in the video clip in order to control for general memory accuracy (table 1). A total memory score out of six was calculated for each participant based on their answers to these questions. Following the completion of the general memory questions participants were asked to answer in a demographic questionnaire before being presented with the debriefing statement outlining the true aims and objectives of the study. Participants were thanked for their participation and had the opportunity to ask questions regarding the study.

Ethical considerations

The current study received ethical approval from the researchers' institutional ethical committee. The study met the criteria for ethical approval and adhered to the necessary ethical guidelines and standards (e.g. anonymity of participants data, participants were given the option to withdraw at any point). The study also adhered to the BPS guidelines referring to the carrying out of research with human participants (BPS Code of Human Research Ethics, 2010). The study also specifically made efforts to adhere to the guidelines relating to working with vulnerable populations, namely those relating to giving such participants sufficient time and opportunity to understand the purpose and possible outcomes of participating in research.

Headway staff were approached in the first instance in order to ascertain the number of participants who would be suitable to take part in the study. This involved going through in detail what would be required from participants as well as providing flyers and information sheets to be handed out to members ahead of recruitment. It was made clear that the researcher would be taking the lead from Headway staff as to who would be suitable to approach to take part in terms of ability to provide informed consent. All participants were required to sign a consent form before taking part in the study.

The decision was taken to refer to the man in the video clip used as a *trespasser*. This is different to the description used in the Wells et al. (2003) study whereby the suspect was referred to as the *rooftop bomber.* The decision was made to refer to the suspect as a trespasser in this instance due to the possibly traumatic or violent connotations that may lead to distress or upset for vulnerable participants. The video does not show any violent behaviour but the man in question can be seen initially holding something metal when viewed on the roof. It was not deemed to be obvious that this was intended to show a man making/planting a bomb and so the man seen in the video is described as trespassing for the purposes of the current study.

Results

Preliminary analyses

A series of one-way MANOVA's were run in order to first establish whether there was an even match in terms of cognitive ability (total MoCA score) and general memory ability (total memory score) between the line-up conditions for both the brain injured and non-brain injured participants. The dependant variables were total MoCA score and total general memory score. The independent variables were brain injury (yes/no) and line-up condition (traditional vs confidence rating).

No statistically significant difference was found in cognitive ability or general memory ability based on line-up condition for the brain injured participants, $F(2, 12)= 1.55$, $p= 0.25$; *Wilk's Λ*= 0.74, partial $\eta^2= 0.21$ suggesting that there was no difference in the abilities of the brain injured participants across the two line-up conditions. Similarly, no significant difference was found in cognitive ability or general memory ability across line-up condition for the non-brain injured participants, $F(2, 7)= 0.08$, $p= 0.92$; *Wilk's Λ*= 0.98, *partial* $\eta^2= 0.02$ indicating that these participants were also evenly matched in terms of cognitive and general memory ability.

General memory and cognitive performance

It was hypothesised that brain injured participants would perform less accurately than non-brain injured participants in terms of general cognitive and memory ability. A one-way MANOVA was therefore run in order to compare the overall cognitive and general memory ability of both sets of participants. A statistically significant difference was found in cognitive ability and general memory ability between the brain injured and non-brain injured participants, $F(2, 22)= 9.46$, $p= <0.01$, partial $\eta^2= 0.46$. Univariate tests revealed that brain-injured participants ($M= 21.53$, $SD= 4.54$) performed significantly worse on the MoCA task in comparison to non-brain-injured participants ($M= 26.7$, $SD= 2.16$), $F(1, 23) = 11.52$, $p= < 0.05$, partial $\eta^2= 0.34$. In relation to general memory scores, univariate tests also revealed that brain-injured participants ($M= 3.47$, $SD=.83$) performed significantly worse than non-brain-injured participants ($M= 4.70$, $SD=.95$) $F(1, 23) = 11.77$, $p= < 0.05$, partial $\eta^2= 0.33$. The differences in mean score between brain-injured and non-brain-injured participants for both outcome variables were large, in accordance to Cohen (1988). The mean MoCA and general memory scores across the overall conditions can be seen below (Table 2).

Table 2

Mean MoCA and general memory scores across all conditions

Condition	Mean total MoCA score	Mean general memory score
Brain injury (total)	**21.53 (SD=4.54)**	**3.47 (SD=.83)**
BI x traditional	20.7 (*SD*= 4.83)	3.12 (*SD*= 0.64)
BI x confidence rating	22.4 (*SD*= 4.20)	3.90 (*SD*= 0.81)
Non-brain injury (total)	**26.7 (SD=2.16)**	**4.7 (SD=.95)**
NBI x traditional	26.4 (*SD*= 2.90)	4.8 (*SD*= 1.10)

NBI x confidence rating	27.0 (SD= 1.41)	4.6 (*SD*= 0.90)

Note: BI= Brain Injury, NBI= No Brain Injury

False identification

It was hypothesised that brain injured participants would be more likely than non- brain injured participants to make a false identification across the two line-up conditions. It was also hypothesised that brain injured participants in the confidence ratings line-up condition would be less likely to make a false identification than those in the traditional line-up condition. The majority (13) of brain injured participants made a false identification and all of the brain injured participants in the traditional line-up condition made a false identification. Similar data was found within the non-brain injured condition in that four out of five participants in the traditional line-up condition made a false identification (see Fig. 1).

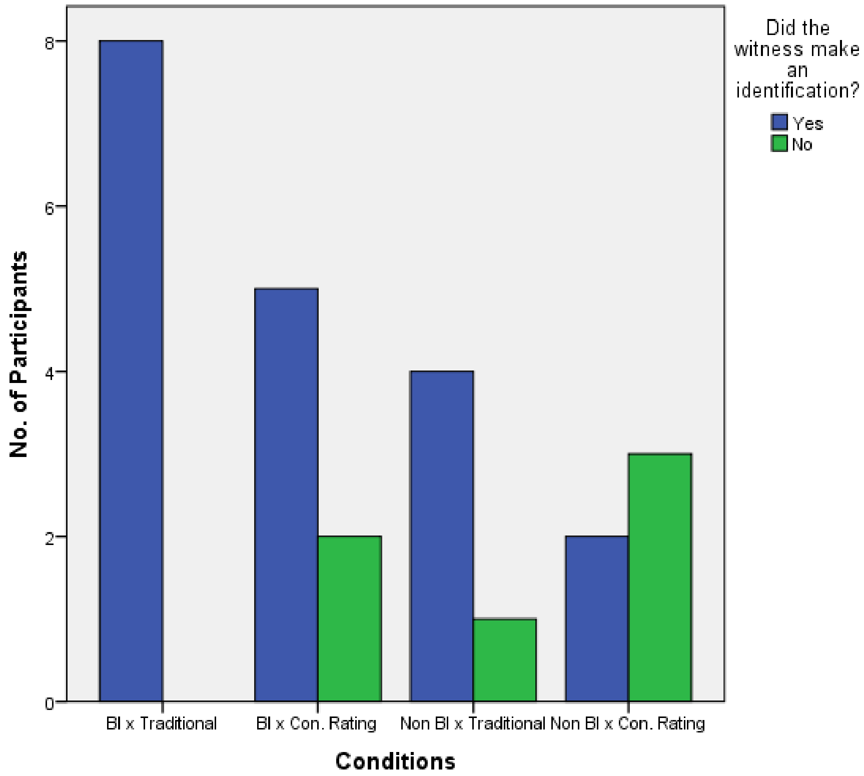

Figure 1. False identification rates for all conditions.

Direct logistic regression was performed to assess the impact of a number of factors on the likelihood that respondents would make an identification on a target-absent line-up. The model contained four independent variables (brain injury, line-up procedure, general memory score, and cognitive ability). Preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, and homoscedasticity. The full model containing all predictors was statistically significant, $\chi 2$ (4, N = 25) = 14.82, $p < .01$, indicating that the model was able to distinguish between participants who made a false identification and participants who made no identification. The model as a whole explained between 44.7% (Cox and Snell R square) and 67% (Nagelkerke R squared) of the variance in eyewitness misidentification, and correctly classified 88% of cases. As shown in Table 3, only one of the independent variables made a unique statistically significant contribution to the model. The strongest — and only significant — predictor of false identification was general memory score, recording an odds ratio of .09. This indicated that respondents who had higher scored higher on general memory were less likely to make a false identification than those who scored lower on the general memory test, controlling for all other factors in the model. Despite the descriptive data suggesting a difference in false identification rates between brain-injured and non-brain-injured participants; and between traditional and confidence rating procedures, the analyses indicated that these differences were not statistically significant. Inspection of the confidence intervals (see Table 3) suggests that the insignificant findings may have been a result of the small sample size.

Table 3.

Binary logistic regression model for false identification rates.

	False identification (*N*=19)[a]	
Variable	SE	OR (95% CI)
General memory score	1.22	.09 (.01/.97)*
MoCA score	.23	.94 (.59/1.48)
Brain injury		
Present	2.82	178.89 (.71/45184.95)
Not-present	1	1
Line-up procedure		
Traditional	2.2	65.57 (.89/4824.08)
Confidence rating	1	1

Note. a= Reference group: ‘No identification’ (*N*=6); OR = Odds Ratio. SE = Standard Error. 95% CI = Confidence Interval. * $p<.05$.

Discussion

The present study aimed to compare the performance of individuals with a mild to moderate brain injury to controls in two target-absent line-up procedures: a traditional simultaneous procedure requiring a binary "yes/no" answer and a sequential procedure using confidence ratings. The present study also aimed to compare the utility of the two line-up conditions with brain injured witnesses in reducing the likelihood of false identifications.

It was hypothesised that brain injured participants would perform less well on measures of general memory and cognitive ability. A statistically significant difference was found between the brain injured and non-brain injured participants in terms of total MoCA scores and general memory scores, suggesting that overall, the brain injured group were less able in these areas. This is in line with numerous previous studies showing the various memory and cognitive impairments that can result from a brain injury (e.g. Vanderploeg et al., 2001; Wammes et al., 2017; Shum, et al., 2014). Such deficits in areas of cognition such as visual memory and facial recognition could affect how an individual performs in eyewitness tasks such as police line-ups: a reduced ability to encode and store visual information (e.g. details seen in a short video clip) will limit an individual's ability to then be able to recall said information even a few minutes later (Schum, Harris & O'Gorman; 2000). Other research has consistently found that brain injury can cause a general decline in cognitive function across a wide range of domains— even many years after an injury has been sustained (Hoofien, Gilboa, Eli Vakil & Donovick, 2001). The present findings suggest that brain injured witnesses may carry various cognitive impairments that may make engaging in procedures such as police line-ups more challenging. Further research would be well placed to specifically examine the relationship between different cognitive processes and memory recall and determine how impairments in these different areas may be more or less likely to hinder performance in eyewitness line-up procedures. Similarly, future research could look at whether different line up techniques are more or less effective at reducing false identifications in brain injured witnesses with different patterns of impairment as this can vary between type of injury sustained.

It was also hypothesised that participants with a brain injury would be more likely to make a false identification than the control group, across the two line-up conditions; and that brain injured participants in the confidence ratings condition would be less likely to make a false identification than brain injured participants in the traditional line-up condition. A Binary logistic regression analysis showed that line-up condition and brain injury could not in fact reliably predict whether or not a participant made a false identification. This finding is in contrast to numerous studies that have been conducted previously demonstrating the utility of sequential line-up procedures (e.g Lindsay & Wells, 1985; Steblay et al., 2001) and confidence ratings (e.g. Sauer et al., 2008, 2010) in reducing the likelihood of false identifications. There are several possible reasons that the insignificant findings with regard to brain injury and line-up procedure predicting false identification. Firstly, the limited sample size of the study may have prevented the results reaching significance. The confidence interval scores suggest that a larger sample would be needed to reliably investigate the effectiveness of the aforementioned variables as predictors for false identification (see Table 3). When looking at the descriptive results (figure X), it can be seen that 13 out of 15 (86.7%) brain injured participants made a false identification compared to 7 out of 10 non-brain injured participants (70%). With a greater number of participants this difference may have reached significance. Both the brain injury and non-brain injury groups behaved similarly across the two line-up conditions, in that both sets of participants in the traditional line-up condition were more likely to make a false identification than those in the confidence rating condition, although this difference was not statistically significant. Again, the limited sample size may provide a reason for this.

Failure to find statistically significant support for the latter two hypotheses may also be due to the fact that brain injured participants are in fact no more likely to make a false identification than the general population. This is in contrast to previous research suggesting that witnesses with cognitive or intellectual impairments are more likely to make unreliable witnesses (Kwong See et al., 1998) and that police and jury members are therefore less likely to consider such individuals reliable witnesses (Stobbs & Kebbell, 2003). The results of the current study suggest that brain injured eyewitnesses are no more likely to make a false identification than a non-brain injured witness despite previous literature suggesting that they may lack certain cognitive abilities and may be subjected to bias and are predisposed to being considered unreliable witnesses. It is possible that the reason for these findings are that the brain-injured, and non-brain-injured group were more similar in terms of cognitive ability than was identified by the MoCA and general memory questions asked in the present study. The results suggest that the brain injured group performed worse on the general measure of cognitive ability (MoCA) and were less accurate in answering the six general memory questions however, a more in-depth assessment of each individual participant's abilities may have revealed less of a difference between the two groups. The MoCA for example is a broad assessment designed to be administered quickly and used for identifying gross deficits in a select few areas of cognition. Given the small sample size, it may be that the brain injured participants in the current study did not have significant impairments in the areas of visual memory or facial recognition or did not have impairments in these areas to the extent that it would significantly impair them in a line-up situation. Further studies would have more scope to assess individual areas of cognition in more depth in order to make more specific comparisons of ability between the brain injured and non-brain injured groups. It is also worth noting however, that all brain injured participants in the present study were interviewed on a one to one basis, in a familiar environment and were not exposed to any violent or potentially traumatic material. It may be that individuals with a brain injury are capable of providing reliable and valuable eyewitness identifications, provided the right social and environmental factors are put in place to reduce any additional stress and anxiety. Social and environmental factors may therefore be able to help overcome any mild impairments in specific cognitive areas related to performance in line-up situations.

With regard to the practical implications of the present findings, despite previous literature suggesting that individuals with brain injury would be subjected to bias and possibly not considered reliable witnesses (Linden & Crothers, 2006; Write & Holiday, 2005), the results of the current study suggest that they are at least no more statistically likely to make a false identification than a witness without a brain injury or cognitive impairment. Practically speaking, more training for police officers and jurors regarding the potential of brain injured witnesses is needed to avoid evidence given by such individuals being disregarded unnecessarily. Further research in the area would help inform education and training regarding the nature of brain injury and what — if anything— is needed to ensure that a witness with a brain injury can engage fully with a line-up procedure and provide reliable evidence. Theoretically, there is little empirically to suggest whether brain injury does or does not affect one's ability to provide reliable evidence. Certain hypotheses can be made regarding previous research looking at the performance of individuals with developmental disorders and intellectual ability however, with the effects of brain injury being so varied, it may be that such individuals are best studied as a distinct population.

An interesting and unexpected finding of the current study was that participants who performed better on the general memory recall questions were over 11 times more likely to make a false identification. This was unexpected as previous research has suggested that witnesses with intellectual disability—who may exhibit similar memory impairments to brain injured witnesses—are more likely to make a false identification (Ericson & Issacs, 2013). One possible reason for this unexpected finding is that witnesses with greater recall ability may in turn also have greater insight into their abilities and limitations. As a result, they may then be less uncertain when faced with a target-absent line-up and thus, would be more willing to make an identification. Conversely, those individuals who have greater memory deficits, and are aware of them, may be less confident in their abilities and so, would be less likely to make an identification. Kennedy (2001) found some support for this theory in that brain injury survivors were more likely to be over-confident than controls and displayed higher retrospective confidence judgements when making interference errors. This suggests that brain-injured individuals who are confident in their abilities (i.e. due to having greater memory capabilities) may be more prone to overestimating their ability in a line-up situation and therefore be more likely to make a false identification in a target-absent line-up due to being less uncertain. Indeed, Deffenbacher (1980) reported that very little correlation can be found between the confidence of an eyewitness and their accuracy. Future research could explore this further by looking at how levels of insight and confidence influence false identifications in brain injured witnesses. One implication of the above finding may relate to the tendency of jurors to be more likely to believe confident witnesses (Wells, Lindsay & Ferguson, 1979).

Limitations and directions for future research

The current study was carried out as a preliminary investigation to highlight potential directions for future research. Owing to the vulnerability and rarity of the targeted participants, the study was conducted on a relatively small sample. It is unclear whether a larger sample size would cause a significant change to the findings. However, the implementation of a larger sample size would strengthen the external validity of the observed findings and reduce the risks of both type one and type two errors being made. Future research has potentially more scope to explore this further with a larger sample of brain injured participants. This would add to the currently very limited amount of research currently that specifically looks at the abilities of brain injured individuals to be reliable eyewitnesses.

Some recommendations for future research have been mentioned above. Namely, more specific assessments of cognitive ability, especially in areas of visual memory and facial recognition would allow for more specific comparisons between brain injured and non-brain injured groups. It would also allow for any variation within brain injured groups to be seen and therefore for suggestions to be made regarding the appropriateness of different line-up procedures for differing levels and types of impairment. Future research looking at how levels of insight into abilities and confidence in decision making influence false identification would shed more light on the finding that those participants with greater memory ability were more likely to make a false identification. It would again allow for a greater understanding of the within-group differences among individuals with brain injuries.

Conclusion

In conclusion, the current study found that despite demonstrating poorer recall and general cognitive ability brain injured witnesses were no more likely than controls to make a false identification on a target-absent line-up in either a simultaneous or sequential confidence rating procedure. The results of the current study suggest that the potential biases or stereotypes held about victims of brain injury and individuals with cognitive impairment by the police or jurors may be unfounded and that witnesses with a brain injury can provide reliable evidence given the right circumstances. It may be that further education and training is needed about brain injury and the implications thereof in order for such witnesses to be able to engage in line-up procedures effectively. Indeed, much more empirical work is needed looking at brain injured witnesses as a discrete population in order to fully establish what accommodations may need to be made.

The current study produced some unexpected findings suggesting that individuals with greater memory abilities were more likely to make a false identification in a target-absent line-up. It is proposed that this may be due to an overconfidence effect in that brain injured witnesses with greater abilities may be more likely to feel confident in making an identification but are also therefore more likely to make an error in doing so. Implications may relate to the tendency of jurors to be more likely to believe the evidence of confident witnesses may not always be appropriate with witnesses with a brain injury

References

Agnew, S. E., & Powell, M. B. (2004). The effect of intellectual disability on children's recall of an event across different question types. *Law and Human Behavior, 28*(3), 273-294. doi:LAHU.0000029139.38127.61

Babbage, D. R., Yim, J., Zupan, B., Neumann, D., Tomita, M. R., & Willer, B. (2011). Meta-analysis of facial affect recognition difficulties after traumatic brain injury. *Neuropsychology, 25*(3), 277-285. doi:10.1037/a0021908

Behrman, B. W., & Davey, S. L. (2001). Eyewitness identification in actual criminal cases: An archival analysis. *Law and Human Behavior, 25*(5), 475-491. doi:1012840831846

Brewer, N., & Palmer, M. A. (2010). Eyewitness identification tests. *Legal and Criminological Psychology, 15*(1), 77-96. doi:10.1348/135532509X414765

Brewer, N., & Wells, G. L. (2011). Eyewitness identification. *Current Directions in Psychological Science, 20*(1), 24-27. doi:10.1177/0963721410389169

Brewer, N., Weber, N., Wootton, D., & Lindsay, D. S. (2012). Identifying the bad guy in a lineup using confidence judgments under deadline pressure. *Psychological Science, 23*(10), 1208-1214. doi:10.1177/0956797612441217

British Psychological Society. (2010). *Code of Human Research Ethics* [PDF format]. Retrieved from: http://www.bps.org.uk/sites/default/files/documents/code_of_human_research_ethics. Pdf

Christodoulou, C., DeLuca, J., Ricker, J., Madigan, N., Bly, B., & Lange, G. et al. (2001). Functional magnetic resonance imaging of working memory impairment after traumatic brain injury. *Journal Of Neurology, Neurosurgery & Psychiatry*, *71*(2), 161-168. http://dx.doi.org/10.1136/jnnp.71.2.161

Cohen, J. (1988). Statistical power analyses for the behavioural sciences. New York, NY: Routledge Academic.

Davidson, O. B., & Eden, D. (2000). Remedial self-fulfilling prophecy: Two field experiments to prevent golem effects among disadvantaged women. *Journal of Applied Psychology, 85*(3), 386-398. doi:10.1037//0021-9010.85.3.386

Elizabeth Brimacombe (ne Luus), C A, Quinton, N., Nance, N., & Garrioch, L. (1997). Is age irrelevant? perceptions of young and old adult eyewitnesses. *Law and Human Behavior, 21*(6), 619-634.

Ericson, K., & Isaacs, B. (2003). Eyewitness identification accuracy: A comparison of adults with and those without intellectual disabilities. *Mental Retardation, 41*(3), 161.

Headway. (2017a). *Cognitive effects of brain injury*. Retrieved from: https://www.headway.org.uk/about-brain-injury/individuals/effects-of-brain-injury/cognitive-effects/

Headway. (2017b). *Types of Brain Injury*. Retrieved from: https://www.headway.org.uk/about-brain-injury/individuals/types-of-brain-injury/

Headway. (2017c). *About Headway*. Retrieved from: https://www.headway.org.uk/about- headway/

Hiday, V., Swartz, M., Swanson, J., Borum, R., & Wagner, H. (1999). Criminal victimization of persons with severe mental illness. *Psychiatric Services*, *50*(1), 62-68. http://dx.doi.org/10.1176/ps.50.1.62

Kennedy, M. R. (2001). Retrospective confidence judgements made by adults with traumatic brain injury: Relative and absolute accuracy. *Brain Injury, 15*(6), 469-487.

Knox, L., & Douglas, J. (2009). Long-term ability to interpret facial expression after traumatic brain injury and its relation to social integration. *Brain and Cognition, 69*(2), 442-449. doi:10.1016/j.bandc.2008.09.009

Kwong See, S. T., Hoffman, H. G., & Wood, T. L. (2001). Perceptions of an old female eyewitness: Is the older eyewitness believable? *Psychology and Aging, 16*(2), 346-350. doi:10.1037/0882-7974.16.2.346

Levin, H. S. (1990). Memory deficit after closed-head injury. *Journal of Clinical and Experimental Neuropsychology, 12*(1), 129-153. doi:10.1080/01688639008400960

Linden, M. A., & Crothers, I. R. (2006). Violent, caring, unpredictable: Public views on survivors of brain injury. *Archives of Clinical Neuropsychology, 21*(8), 763-770. doi:10.1016/j.acn.2006.08.010

Lindsay, R. C., & Wells, G. L. (1985). Improving eyewitness identifications from lineups: Simultaneous versus sequential lineup presentation. *Journal of Applied Psychology*, 70(3), 556.

Loftus, E. F. (1996). *Eyewitness testimony* (New ed.). Cambridge, Mass; London: Harvard University Press.

Mantell, A. (2010). Traumatic brain injury and potential safeguarding concerns. *The Journal of Adult Protection, 12*(4), 31-42. doi:10.5042/jap.2010.0642

Manzanero, A. L., Contreras, M. J., Recio, M., Alemany, A., & Martorell, A. (2012). Effects of presentation format and instructions on the ability of people with intellectual disability to identify faces. *Research in Developmental Disabilities, 33*(2), 391-397. doi:10.1016/j.ridd.2011.09.015

Mathias, J., & Wheaton, P. (2007). Changes in attention and information-processing speed following severe traumatic brain injury: A meta-analytic review. *Neuropsychology*, *21*(2), 212-223. http://dx.doi.org/10.1037/0894-4105.21.2.212

Mojtahedi, D., Ioannou, M. and Hammond, L. (2017). Personality correlates of co-witness suggestibility. *Journal of Forensic Psychology Research and Practice.* 17 (4), 249-274. DOI: 10.1080/24732850.2017.1358996

Nasreddine, Z. S., Phillips, N. A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., . . . Chertkow, H. (2005). The montreal cognitive assessment, MoCA: A brief screening tool for mild cognitive impairment. *Journal of the American Geriatrics Society, 53*(4), 695-699. doi:10.1111/j.1532-5415.2005.53221.x

NICE (2014). Head injury: assessment and early management. Retrieved from https://www.nice.org.uk/guidance/cg176

Norheim, N. J., & Ferraro, F. R. (2016). Eyewitnesses with pervasive developmental disorders. *Psychiatry, Psychology and Law, 23*(5), 670-675. doi:10.1080/13218719.2015.1084663

Pozzulo, J. D., & Lindsay, R. C. L. (1998). Identification accuracy of children versus adults: A meta-analysis. *Law and Human Behavior, 22*(5), 549-570. doi:1025739514042

Sauer, J. D., Brewer, N., & Weber, N. (2008). Multiple confidence estimates as indices of eyewitness memory. *Journal of Experimental Psychology: General, 137*(3), 528-547. doi:10.1037/a0012712

Sauer, J. D., Palmer, M. A., & Brewer, N. (2017). Mock-juror evaluations of traditional and ratings-based eyewitness identification evidence. *Law and Human Behavior,* doi:10.1037/lhb0000235

Semmler, C., Brewer, N., & Douglass, A. B. (2011). Jurors believe eyewitnesses. In B. L. Cutler (Ed.), *Conviction of the innocent: Lessons from psychological research* (pp. 185–209). Washington, DC: American Psychological Association.

Shum, D. H. K., Harris, D., & O'Gorman, J. G. (2000a). Effects of severe traumatic brain injury on visual memory. *Journal of Clinical and Experimental Neuropsychology, 22*(1), 25-39. doi:1;1-8;FT025

Shum, D. H. K., Harris, D., & O'Gorman, J. G. (2000b). Effects of severe traumatic brain injury on visual memory. *Journal of Clinical and Experimental Neuropsychology, 22*(1), 25-39. doi:1;1-8;FT025

Spikman, J. M., Milders, M. V., Visser-Keizer, A. C., Westerhof-Evers, H. J., Herben-Dekker, M., & van der Naalt, J. (2013). Deficits in facial emotion recognition indicate behavioral changes and impaired self-awareness after moderate to severe traumatic brain injury. *PLoS ONE, 8*(6), e65581. doi:10.1371/journal.pone.0065581

Sporer, S. L. (1993). Eyewitness identification accuracy, confidence, and decision times in simultaneous and sequential lineups. *Journal of Applied Psychology, 78*(1), 22-33. doi:10.1037/0021-9010.78.1.22

Steblay, N. K., Dysart, J. E., & Wells, G. L. (2011). SEVENTY-TWO TESTS OF THE SEQUENTIAL LINEUP SUPERIORITY EFFECT: A meta-analysis and policy discussion. *Psychology, Public Policy, and Law, 17*(1), 99-139. doi:10.1037/a0021650

Steblay, N., Dysart, J., Fulero, S., & Lindsay, R. C. L. (2001). Eyewitness accuracy rates in sequential and simultaneous lineup presentations: A meta-analytic comparison. *Law and Human Behavior*, 25(5), 459-473. doi:10.1023/A:1012888715007

Stobbs, G., & Kebbell, M. R. (2003). Jurors' perception of witnesses with intellectual disabilities and the influence of expert evidence. *Journal of Applied Research in Intellectual Disabilities, 16*(2), 107-114. doi:10.1046/j.1468-3148.2003.00151.x

Ternes, M., & Yuille, J. C. (2008). Eyewitness memory and eyewitness identification performance in adults with intellectual disabilities. *Journal of Applied Research in Intellectual Disabilities, 21*(6), 519-531. doi:10.1111/j.1468-3148.2008.00425.x

Vanderploeg, R. D., Crowell, T. A., & Curtiss, G. (2001). Verbal learning and memory deficits in traumatic brain injury: Encoding, consolidation, and retrieval. *Journal of Clinical and Experimental Neuropsychology, 23*(2), 185-195. doi:10.1076/jcen.23.2.185.1210

Wammes, J. D., Good, T. J., & Fernandes, M. A. (2017). Autobiographical and episodic memory deficits in mild traumatic brain injury. *Brain and Cognition, 111*, 112-126. doi:10.1016/j.bandc.2016.11.004

Warren, M. (1993). A hierarchical model for evaluation and treatment of visual perceptual dysfunction in adult acquired brain injury, Part 1. *American Journal Of Occupational Therapy*, *47*(1), 42-54. http://dx.doi.org/10.5014/ajot.47.1.42

Wells, G. L. (1984). How adequate is human intuition for judging eyewitness memory? In G. L. Wells & E. Loftus (Eds.), *Eyewitness testimony. Psychological perspectives* (pp. 256–272). New York: Cambridge University Press.

Wells, G. L. (1993). What do we know about eyewitness identification? *American Psychologist, 48*(5), 553-571. doi:10.1037/0003-066X.48.5.553

Wells, G. L., Lindsay, R. C., & Ferguson, T. J. (1979). Accuracy, confidence, and juror perceptions in eyewitness identification.*Journal of Applied Psychology, 64*(4), 440.

Wells, G. L., Olson, E. A., & Charman, S. D. (2003). Distorted retrospective eyewitness reports as functions of feedback and delay. *Journal of Experimental Psychology: Applied, 9*(1), 42-52. doi:10.1037/1076-898X.9.1.42

Wilcock, R., & Henry, L. (2013). The performance of eyewitnesses with intellectual disabilities on photographic identification line-ups. *International Journal of Disability, Development and Education, 60*(1), 44-52. doi:10.1080/1034912X.2013.757141

Wright, A. M., & Holliday, R. E. (2005). Police officers' perceptions of older eyewitnesses. *Legal and Criminological Psychology, 10*(2), 211-223. doi:10.1348/135532505X37001

Wright, A. M., & Holliday, R. E. (2007). Enhancing the recall of young, young–old and old–old adults with cognitive interviews.*Applied Cognitive Psychology, 21*(1), 19-43. doi:10.1002/acp.1260

Yarmey, A. D. (2000). The older eyewitness. In M. B. Rothman, B. D. Dunlop, & P. Entzel (Eds.), *Elders, Crime and the Criminal Justice System: Myths, Perceptions and Reality in the 21st Century*. (p 127-147). New York, Springer.

Yin, R. K. (1970). Face recognition by brain-injured patients: A dissociable ability? *Neuropsychologia, 8*(4), 395-402.