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## Witnessing an Unfamiliar Person:

The Effects of Distance, Lighting, Age, Line-up Type,  
and Line-up Position on Eyewitness Accuracy





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# Abstract

In criminal cases, DNA evidence is considered circumstantial evidence, whereas an identification by an eyewitness, after having observed a perpetrator commit a criminal act, is considered direct evidence of a suspect's guilt. When the police have a suspect in custody and an eyewitness identifies the suspect as the perpetrator of a crime there are, however, many factors that influence eyewitness accuracy. For example, viewing conditions and the age of the eyewitness affect how the eyewitness observes and encodes the perpetrator. Other factors, such as the line-up type used to test the witness, are likely to influence how the eyewitness makes the identification. Importantly, it has been shown that in almost 1900 post-conviction exoneration cases, 70% of the original convictions included misidentifications by eyewitnesses. In the present thesis, we investigated the visual limits of eyewitness accuracy with the aim of finding a threshold where accuracy is so low that identifications should not be used as evidence. We also investigated how the age of the eyewitness and line-up type moderate the visual boundaries of eyewitness accuracy.

**Study I.** When the distance between an eyewitness and a perpetrator increases, eyewitness accuracy decreases. An upper distance threshold after which accurate decisions are extremely unlikely has, however, not been established empirically. We investigated this boundary and assessed if the age of the eyewitness and line-up type moderate the effect of distance. We expected that increased distance would affect accuracy negatively, and that young children (6–11) and older adults (45–77) would fare worse compared with young adults (18–44). We presented four live targets (i.e., the “perpetrators” to be observed), with each target being presented at one distance between 5 and 110 meters. We used two common photograph line-ups, in which eight line-up images were either presented sequentially (one by one) or simultaneously (all at the same time). The actual perpetrator was either present in (target present) or absent from (target absent) the line-up. Based on 6233 line-up decisions from 1588 participants, we found a dramatic negative effect of increased distance on both target present identification accuracy and target absent rejection accuracy. We also found that young children and older adults were less accurate compared with young adults and reached the visual threshold at a lower distance. Simultaneous line-ups produced slightly higher accuracy rates in target present line-ups compared with sequential line-ups, but overall the effect of increased distance was similar. The overall accuracy was only approximately 50% at 5–10 meters, decreasing to approximately 30% by 40 meters, and by 100 meters, the accuracy reached a visual threshold for reliable eyewitness identification. High confidence and shorter response times were postdictive of identification accuracy at distances of up to 40 meters. These findings pertain to the debate concerning the use of confidence and response times as postdictive measures of accuracy, as earlier studies have not systematically investigated these aspects in a live setting which included long distances.

**Study II.** Although lower lighting has a negative effect on identification accuracy, the interactive effects of distance and lighting on the visual limits of accuracy have not been investigated in a live setting. We investigated three levels: Low lighting (i.e., moonlight condition), medium lighting (i.e., twilight condition), and high lighting (i.e., office space condition) at eight distances between 6 and 20 meters. Based on 1318 decisions from 178 participants in simultaneous target present (forced choice) line-ups, we found that both lower lighting and increased distance decreased accuracy. At 20 meters in the lowest lighting condition, accuracy was at chance level (i.e., similar to guessing). The results indicate that lower lighting dramatically shortens the upper distance threshold found in Study I. As we did not include target absent line-ups or the possibility to reject the line-ups, the results are not as generalizable as the results from Study I. As previously observed, we found that high confidence and shorter response times were postdictive of identification accuracy.

**Study III.** As sequential and simultaneous photograph line-ups differ in how line-up members (i.e., images) are presented to eyewitnesses, we investigated how eyewitnesses make selections based on the positions of the images in the line-up. These analyses were based on the same data as Study I and IV. Earlier studies suggest that in sequential line-ups, eyewitnesses tend to avoid the first line-up position and if they are informed of the number of images to be shown, they show a tendency to select from the positions at the end of the line-up. In simultaneous line-ups results regarding position effects vary, but recent studies suggest that there is a top row preference. We found that increased distance resulted in an increase of first line-up position selections in sequential line-ups for all age groups, but that young children showed the highest tendency to select from the first line-up position. Additionally, both young children (6–11) and the oldest adults (60–77) made more erroneous first line-up position selections compared with young adults and they also made more erroneous first line-up position selections compared with selections in line-up positions 2–8. In simultaneous line-ups, we found a weak top row preference. Based on the large sample size, the wide age range included, and our full randomization of image positions, the findings lend support to the interpretation that sequential line-ups should be used with caution with regard to young children and the oldest adults.

**Study IV.** Young children and older adults tend to give less accurate perpetrator descriptions compared with young adults. For young adults, increased distance does not appear to have a negative effect on perpetrator age estimation accuracy, but height and weight estimates become less accurate. However, it is unclear how increased distance affects accuracy as regards gender estimation. To date, the effects of increased distance on estimation accuracy have only been investigated up to a distance of 50 meters, and no studies have investigated the combined effect of eyewitness age and viewing distance on estimation accuracy. Here, we investigated the effects of increased distance and eyewitness age on the accuracy of perpetrator characteristic estimations. After observing a live target, we asked participants to estimate the target's gender, age, height, and weight. We found that a high accuracy ( $\pm 2$  units of the actual value) of age, height, and weight estimation was rare, but

that accurate gender estimation was the norm. With increased distance, the accuracy of gender, age, and height estimation but not weight estimation decreased, and young children (6–11) and older adults (45–77) performed less accurately than young adults (18–44). We also found that serious errors (i.e., more than +/- 10 units) in the estimations of age, height, and weight and incorrect gender estimates became more likely as distance increased. However, especially young children (6–11) and to a certain extent also older children (12–17) and older adults (45–77) made more serious error estimates compared with young adults (18–44). Overall, young children and older adults were less accurate and more likely to produce serious errors than were young adults. The increase in serious errors is worrying because such errors may result in the exclusion of the actual perpetrator if the focus is placed on the wrong suspect characteristics during an investigation.

**Conclusions.** The four studies included in this thesis are based on two samples with a total of 1766 participants and 7657 line-up decisions in a live ecological setup. To the best of our knowledge, the data collection of Study I represents the largest live eyewitness experiment ever conducted. Our sample is also unique in that it contains an age range between 6 and 77 years of age. The findings of our studies are thus highly generalizable. These studies are the first to establish upper visual identification thresholds for reliable eyewitness identification. In optimal viewing conditions (i.e., no distractions, daylight, a 20 second duration) eyewitness accuracy was only approximately 50% at 5–10 meters. At 40 meters, the accuracy was at approximately 30%, and after 100 meters, line-ups had no added value. As there were age differences, both age and distance need to be considered together. We also found that in low light the upper distance threshold is considerably shorter; after 20 meters identification accuracy is at chance level.

Our analyses of confidence and response times are largely in line with previous findings regarding their postdictive value. However, we found that this positive association only applies up to approximately 40 meters, past which the relationship is no longer as clear. Study I represents the first experiment to have assessed the postdictive value of confidence and response times at distances up to 110 meters and thus is an important contribution to the literature. At greater distances, the likelihood of making serious estimation errors of perpetrator characteristics also increased, aggregating the risk of the police searching for the wrong person. Significantly, we found that as distance increased, first position selections in sequential line-ups increased for all age groups. Moreover, young children and the oldest adults showed worse calibration in the first line-up position versus subsequent line-up positions. We have interpreted these results as indirect support for the possibility that some young children make more errors in first line-up positions due to inhibition deficits and some older adults make errors due to reliance on familiarity rather than recollection. However, future research is needed to confirm these interpretations.



## Svensk sammanfattning

I brottsutredningar betraktas DNA-spår som ett indirekt bevis för en misstänkt persons skuld medan en ögonvittnesidentifikation betraktas som ett direkt bevis för skuld. Tillförlitligheten av ögonvittnesidentifikationer kan trots detta påverkas av många olika faktorer som exempelvis distansen till gärningspersonen, hur mörkt det var vid brottstillfället, ögonvittnets ålder, eller bilduppställningsmetod för ögonvittnesidentifikationen. Hittills har studier av ca 1900 felaktigt dömda oskyldiga individer visat att 70% av fallen inkluderat en eller flera felaktiga ögonvittnesidentifikationer.

I föreliggande avhandling och de fyra tillhörande studierna avhandlas våra utredningar av hur ökad distans, sänkt belysning, ögonvittnets ålder, samt bilduppställningsmetod och bildposition påverkar ögonvittnestillförlitlighet. Målsättningen var att undersöka en gräns efter vilken yttre visuella omständigheter försvårar ögonvittnesidentifikationer till den grad att det är mycket osannolikt att ett ögonvittne tillförlitligt kan identifiera en gärningsperson som setts genast innan. Tidigare forskning antyder att yngre och äldre ögonvittnen är mindre tillförlitliga än unga vuxna och att ökad distans eller lägre belysning inverkar negativt på tillförlitlighet. Trots detta finns inga tidigare studier av möjliga gränsvärden för ögonvittnestillförlitlighet på basen av distans, belysning eller ålder. Sådana värden kunde användas i juridiska sammanhang för att inkludera eller exkludera ögonvittnen i brottsutredningar.

**Studie I.** Vårt syfte var att hitta en gräns för distansen efter vilka korrekta ögonvittnesidentifikationer är mycket osannolika. Vi presenterade deltagare med fyra individer ("gärningspersoner") i taget och utan störande moment på olika avstånd mellan 5 och 110 meter. Genast efter varje observation bad vi deltagarna identifiera gärningspersonen de just sett från en uppställning bilder. De kunde också avstå från att identifiera någon. Vi använde två olika bilduppställningsmetoder där bilderna presenterades endera samtidigt (dvs. simultant) eller en i taget (dvs. sekventiellt). En bild på gärningspersonen var endera ingå eller inte ingå bland de uppställda bilderna. Våra huvudsakliga fynd, baserat på 6233 beslut från 1588 deltagare (6–77 år), var att ett ökat avstånd till gärningspersonen hade en dramatisk negativ effekt på ögonvittnestillförlitlighet, samt att yngre barn och äldre vuxna gjorde fler misstag jämfört med yngre vuxna. Överlag fann vi att sannolikheten att göra en korrekt identifikation låg på ungefär 50 % redan vid 5–10 meters avstånd och på ungefär 30 % vid 40 meter. Vid 100 meter var tillförlitligheten så låg att vi fastställde detta som en övre gräns för ögonvittnestillförlitlighet.

**Studie II.** Här undersökte vi gränsen för ögonvittnestillförlitlighet beroende på tre ljusstyrkor (låg, medel och hög belysning). Deltagare presenterades med åtta olika gärningspersoner på olika avstånd mellan 6 och 20 meter. Till skillnad från i Studie I använde vi endast simultana uppställningar av bilder där en bild på gärningspersonen alltid var närvarande, och det fanns inte möjlighet att avstå från att identifiera någon.

Våra huvudsakliga fynd, baserat på 1318 beslut från 178 deltagare, var att både lägre belysning och ökat avstånd minskade tillförlitligheten. I den lägsta belysningen fann vi att ögonvittnestillförlitlighet var på chansnivå (dvs. samma som att gissa utan att ha sett någon) vid 20 meter. Även om resultaten stödde våra förväntningar om en lägre distansgräns då belysningen är lägre, är generaliserbarheten av detta fynd lägre än i Studie I på grund av metodologiska begränsningar.

**Studie III.** Baserat på samma data som Studie I undersökte vi här hur distans och ålder påverkar val bland bildpositionerna. Vi fann att med ökad distans så ökade tendensen att välja den första bilden som presenterades i sekventiella uppställningar. Yngre barn gjorde flest val och både yngre barn och äldre vuxna var sämre på att göra tillförlitliga beslut i den första positionen jämfört med positionerna 2–8. I simultana uppställningar fanns en tendens att välja från den översta raden. Fynden från de sekventiella uppställningarna tyder eventuellt på att lägre inhibition hos yngre barn och mer minnessvårigheter hos äldre vuxna påverkar deras tendens att välja första positionen i sekventiella uppställningar. Fler studier behövs men våra resultat tyder på att sekventiella uppställningar medför mindre tillförlitliga identifikationer bland yngre barn och äldre vuxna.

**Studie IV.** Baserat på samma data som Studie I undersökte vi här hur distans och ålder påverkar sanningshalten av beskrivningar av gärningspersonens kön, ålder, längd och vikt. Tidigare forskning har inte undersökt ålderskillnader i sådana beskrivningar eller hur distanser över 50 meter påverkar dem. Vi undersökte både hög sanningshalt (dvs. +/- 2 enheter från den verkliga åldern, längden och vikten, samt korrekt kön) och låg sanningshalt/grova misstag (dvs. +/- 10 enheter från den verkliga åldern, längden och vikten, samt felaktigt kön). Ökad distans minskade sannolikheten för beskrivningar med hög sanningshalt och ökade sannolikheten för grova fel. Överlag presterade yngre barn och äldre vuxna sämre än yngre vuxna. Ökningen av grova fel med ökad distans är oroväckande eftersom det höjer risken för att polisen får felaktig information och misstänker fel person för ett brott.

**Sammanfattning:** Resultaten som presenteras i denna avhandling baserar sig på två experimentella datainsamlingar där sammanlagt 1766 individer deltog och genomförde totalt 7657 ögonvittnesidentifikationer. Datainsamlingen för Studie I, III och IV är världens hittills största ögonvittnesexperiment där försökspersoner presenterats med verkliga gärningspersoner. Dessutom har inga andra experimentella studier på ögonvittnesmål inkluderat ett lika brett åldersampel (6–77). Det här innebär att resultaten från dessa studier är både generaliserbara och av stor vikt inom ögonvittnesforskningen. Inga tidigare studier har undersökt gränserna för ögonvittnestillförlitlighet och våra resultat antyder att under optimala förhållanden (dvs. inga störande moment, dagsljus, lång exponeringstid; 20 sekunder) låg tillförlitlighet på endast ungefär 50 % vid 5–10 meters avstånd, på ungefär 30 % vid 40 meter, samt var så låg vid 100 meter att vi fastställde detta som en övre gräns för ögonvittnestillförlitlighet.

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Thomas J. Nyman

## List of original publications

- I. Nyman, T. J., Lampinen, J. M., Antfolk, J., Korkman, J., & Santtila, P. (2019). The distance threshold of reliable eyewitness identification. *Law and Human Behavior*, 43(6), 527-541. <http://dx.doi.org/10.1037/lhb0000342>
- II. Nyman, T. J., Antfolk, J., Lampinen, J. M., Tuomisto, M., Kaakinen, J. K., Korkman, J., & Santtila, P. (2019). A stab in the dark: The distance threshold of target identification in low light. *Cogent Psychology*, 6(1), 1–23. <https://doi.org/10.1080/23311908.2019.1632047>
- III. Nyman, T. J., Lampinen, J. M., Antfolk, J., Korkman, J., & Santtila, P. (revision submitted). Line-up image position in simultaneous and sequential line-ups: The effects of age and viewing distance on selection patterns.
- IV. Nyman, T. J., Lampinen, J. M., Antfolk, J., Korkman, J., & Santtila, P. (accepted). The effects of distance and age on the accuracy of estimating perpetrator gender, age, height, and weight by eyewitnesses. *Psychology, Crime & Law*.

# 1 Introduction

## 1.1 Eyewitness Accuracy

When an eyewitness sees a perpetrator commit a crime and the police later ask the witness to try to identify the perpetrator from a photograph line-up that contains the police suspect, an identification of the suspect is viewed as *direct evidence* of the suspect's guilt; in contrast to *circumstantial evidence*, such as, DNA traces (Wells, Memon, & Penrod, 2006). Moreover, eyewitness identifications frequently play an important role in the judicial system, often having an influential effect on judges and jurors (Brewer & Wells, 2011; Cutler, Penrod, & Dexter, 1990; Nash, Hanczakowski, & Mazzoni, 2015). Nevertheless, the pitfalls inherent in relying on eyewitness identification are exemplified by the large proportion of misidentifications that have contributed to wrongful convictions. For example, in the National Registry of Exonerations, 70% of approximately 1900 post-conviction exonerations were due to tainted eyewitness identifications (The National Registry of Exonerations, 2019). The consequences of misidentifications are that innocent lives are devastated while criminals walk free.

Due to the risks associated with a high reliance on eyewitness identification within the judicial system, researchers have investigated issues that increase or decrease the likelihood of a correct or incorrect identification. Two main categories of variables are often separated in the literature: 1) *estimator variables* that describe aspects related to the witnessed event that cannot be influenced by the investigators and 2) *system variables* that describe aspects related to obtaining information from the eyewitness that can be influenced by the investigators (Wells, 1978).

In the present thesis and associated studies, we investigated the effects of both estimator variables (i.e., distance, lighting, age) and system variables (i.e., line-up type and line-up position) on eyewitness accuracy. Our main aim was to investigate the visual limits of eyewitness identification set by the objective distance between an eyewitness and a perpetrator, moderated by lighting and the age of the witness. To gain a better understanding regarding the effects of our estimator variables on accuracy, we also included two of the most common photograph line-up types (i.e., sequential and simultaneous line-ups). Surprisingly, although distance and lighting are essential for visual perception, few eyewitness researchers have focused on their effects on accuracy, and to date, there has been no research on the combined effects of age, distance, lighting, line-up type, and line-up position on eyewitness accuracy. That is, how visual limitations due to increased distance and lower light, combined with eyewitness age, impact selection patterns depending on the line-up type used. Moreover, as identification accuracy has been found to be associated with both post line-up confidence and line-up response times, we also included analyses of these factors.

## 1.2 The Effects of Viewing Distance

As might be expected, research on the effects of viewing distance between the witness and the perpetrator have demonstrated that increased distance results in decreased accuracy (Jong, Wagenaar, Wolters, & Verstijnen, 2005; Lampinen, Erickson, Moore, & Hittson, 2014; Lampinen, Roush, Erickson, Moore, & Race, 2015; Lindsay, Semmler, Weber, Brewer, & Lindsay, 2008; Loftus & Harley, 2005; Wagenaar & Van Der Schrier, 1996). Most of these studies have, however, used simulated distance (i.e., using photos and not live targets) and only two studies have used real distances and live targets (Lampinen et al., 2014; Lindsay et al., 2008). The benefit of presenting live targets is that it better mimics real life scenarios, and, as it is unknown to what extent simulated distance corresponds to actual distance in eyewitness research, presenting live targets at real distances offers the most direct investigation of the effects of distance on eyewitness accuracy. When interpreting the effects of distance on eyewitness accuracy, *the Rule of Fifteen* is a heuristic that states that in optimal conditions (i.e., below 15 meters and above 15 lux) diagnosticity will be 15. Diagnosticity is a probative value of guilt where a higher value means that the line-up is providing additional information (i.e., support that a suspect who is identified in a line-up is the actual perpetrator) compared to what is known before the line-up; a value of 15 means that the likelihood is 15 to 1 in favor of the suspect being guilty (Wells & Lindsay, 1980; Wells & Olson, 2002). More recent studies have cast doubt on this rule of thumb, as it suggests a cut-off that has not been found in studies with actual distances and actual targets (Lampinen et al., 2014; Lindsay et al., 2008).

Notably, earlier studies have only looked at distances of up to approximately 50 meters in either live (Lindsay et al., 2008) or simulated conditions (Loftus & Harley, 2005), and no previous research has focused on the upper visual limits of eyewitness accuracy. The basis for assuming that there is a visual threshold is that as distance increases, the image projected onto the retina decreases in size, implying that there are limits to what the human eye can perceive (Lu, Zhong Lin, 2014). As distance increases, the ability to discern details becomes less accurate. In the case of observing the face of a perpetrator, this means that the further away a person is, the less detail of the face can be seen and encoded into memory. This indicates that increased distance can also be viewed as a proxy for facial encoding strength, where shorter distances allow stronger encoding and longer distances allow weaker encoding.

For the present thesis, we systematically investigated distances between 5 and 110 meters to locate a point at which the distance between an eyewitness and a perpetrator was so great that diagnosticity would fall to 1. This is the point at which the line-up is no longer providing added information and any suspect identification is pure chance because eyewitnesses can no longer reliably match who they saw with who they are identifying in the line-up. Here, we treated the viewing distance at which diagnosticity was 1 as the visual identification threshold for reliable eyewitness identification. The results presented here represent the most detailed investigation to date of the effects of distance on eyewitness accuracy in a real-life setting.

### 1.3 The Effects of Lighting

As with increased distance, lower lighting has been shown to have a negative effect on eyewitness accuracy. Previous studies, however, have only investigated simulated lighting (DiNardo & Rainey, 1991; Jong et al., 2005; Wagenaar & Van Der Schrier, 1996). The negative effect of lighting is included in *the Rule of Fifteen* (Jong et al., 2005; Wagenaar & Van Der Schrier, 1996). To date, no eyewitness studies have manipulated real lighting conditions when using live targets. Furthermore, no studies so far have investigated the visual identification threshold for reliable eyewitness identification in different lighting conditions. This gap in the literature is surprising considering the high prevalence of crimes in low lighting conditions; it has been estimated that approximately half of all crimes take place after 8p.m. in low lighting conditions (Felson & Poulsen, 2003). Due to artificial lighting, crimes after 8p.m. do not necessarily take place in low lighting conditions, but the high prevalence of crimes committed during nighttime makes it likely that many criminals will be witnessed in low lighting conditions.

With lower lighting, visual acuity (i.e., the clarity of vision) also decreases (Ferwerda, 1998). This implies that the effects of lower lighting on visual perception are similar to those of increased distance. This is because photopic conditions (i.e., brighter lighting) are associated with high visual acuity and scotopic conditions (i.e., dim lighting) are associated with low visual acuity (Hiraoka, Hoshi, Okamoto, Okamoto, & Oshika, 2015; Tidbury, Czanner, & Newsham, 2016; Zele & Cao, 2015). In the present thesis, we were interested in the interactive effect of increased distance and decreased lighting. Both of these conditions are common in real-life eyewitness settings and both can reduce the ability of an eyewitness to see the face of a perpetrator and to encode it into memory. Thus, we were interested in the combined effects of distance and lighting and the possibility of finding a visual distance threshold for different lighting conditions. To find the point at which accuracy decreased to chance level due to the effects of increased distance and lower lighting, we investigated the effects of distances (6–20 meters) and lighting (0.7 lux, 10 lux, and 300 lux) on identification accuracy.

### 1.4 Age Differences

Research shows that there are age-related differences in line-up identification and rejection accuracy (Erickson, Lampinen, & Moore, 2015; Fitzgerald & Price, 2015; Pozzulo & Lindsay, 1998). The most recent meta-analysis on eyewitness age (Fitzgerald & Price, 2015) found that overall young adults (19–28) choose a line-up member less often and make more correct identifications and more correct rejections compared with children (4–17) and older adults (45–77). Both children and older adults, when compared with young adults, tend to make more choices especially in target absent line-ups (Bartlett, 2014; Bartlett & Memon, 2007; Fitzgerald & Price, 2015).



It has been suggested that the choosing bias found in children and older adults is due to a dependence on familiarity rather than recollection when making an identification decision (Shing et al., 2010). Familiarity refers to associative processing (i.e., something seeming familiar, such as a person), while recollection refers to strategic processing or detail-oriented memory (Jacoby, 1991). The processes underlying familiarity mature at a young age while the processes underlying recollection continue to develop throughout childhood (Anooshian, 1999; Brainerd, Holliday, & Reyna, 2004), which explains why children might rely more on familiarity than recollection (Shing et al., 2010; Shing, Werkle-Bergner, Li, & Lindenberger, 2008). Older adults rely on familiarity due to recollection deficits (Fitzgerald & Price, 2015; Healy, Light, & Chung, 2005). Lower accuracy in children is not thought to be associated with face perception deficits *per se*, as results show that face perception develops early and has matured by 5–7 years of age. Instead, the lower accuracy is thought to be associated with the development of attention and memory (Crookes & McKone, 2009). Research also shows that inhibition continues to develop into adulthood and this may be an additional reason why researchers have found that children and to a certain extent adolescents have an overall bias towards choosing rather than rejecting in line-ups (Fitzgerald & Price, 2015; Nigg, 2000). It has also been suggested that older adults suffer from increased disinhibition, however, the most recent meta-analysis shows that disinhibition is not clearly associated with older adults (Rey-Mermet & Gade, 2018).

Notably, eyewitness research has predominantly been conducted on young adults, with less research conducted on children, even less on adolescents, and least of all on older adults. Furthermore, only a few studies have compared age groups within the same publication (Erickson et al., 2015; Fitzgerald & Price, 2015). In other words, although researchers do not doubt that there are age differences and findings illustrate that children and older adults are less accurate than young adults, comprehensive studies comparing age groups are needed.

In the present thesis, we investigated age differences in Studies I, III, and IV. In Study I, we examined how age moderates the effects of viewing distance and line-up type on eyewitness accuracy. In Study III, we focused on age differences in the effects of distance, line-up type, and line-up position on line-up selection patterns. Lastly, in Study IV, we explored age differences when estimating the characteristics of the observed target (i.e., "perpetrator"). As will be outlined and discussed in the following chapters, there is good reason to suspect that age differences in disinhibition, reliance on familiarity, and memory deficits play a role in overall eyewitness accuracy. Moreover, that these effects interact with the effects of distance and line-up type on identification accuracy, estimation accuracy, and line-up image selection pattern. Nevertheless, in our studies we did not explicitly measure inhibition, familiarity, or recollection strategies, rather these concepts set the framework for our interpretations of the results.

## 1.5 Differences Between Line-up Types

In eyewitness research, photograph line-ups usually consist of 6–8 images. The two most used photograph line-ups are sequential line-ups, where images are shown one after another, and simultaneous line-ups, where images are presented simultaneously on the same page. The main difference between these two line-up types is that sequential line-ups are thought to encourage absolute judgments and simultaneous relative judgements (Lindsay & Wells, 1985). Absolute judgements have also been suggested to be associated with recollection whereas relative judgements have been suggested to be associated with familiarity (Meissner, 2005). For many years there has been an ongoing debate about which line-up type is better at maximizing diagnosticity (Wells, Steblay, & Dysart, 2015), with evidence suggesting that sequential line-ups reduce choosing bias but not accuracy (Steblay, Dysart, Fulero, & Lindsay, 2001; Steblay, Dysart, & Wells, 2011; Wells et al., 2015), perhaps due to a more conservative decision criterion (Palmer & Brewer, 2012). However, using Receiver Operating Characteristics (ROC) analysis, studies have found that simultaneous line-ups lead to higher discriminability, that is, the ability to distinguish between the face of the perpetrator and other faces (Clark, Benjamin, Wixted, Mickes, & Gronlund, 2015; Clark, 2012; Gronlund, Mickes, Wixted, & Clark, 2015; Wixted, Mickes, Dunn, Clark, & Wells, 2016).

In eyewitness research, it is also common to manipulate the line-up so that either the perpetrator is present (i.e., target present line-ups) or absent (i.e., target absent line-ups). This is done to investigate situations where a police suspect is the actual perpetrator versus an innocent suspect and, therefore, in target absent line-ups the perpetrator is usually substituted with a filler (i.e., stand-in) to mimic the inclusion of an innocent suspect. By investigating target present suspect identifications (i.e., the hit rate) and target absent innocent identifications (i.e., false alarm rate) it is possible to assess different aspects of accuracy, such as diagnosticity, discriminability, and choosing bias. Diagnosticity indicates the likelihood the selected person actually is the perpetrator; discriminability indicates the eyewitness's ability to correctly discriminate between the target and an innocent filler; and the choosing bias represents the decision criterion (i.e., the willingness to identify).

Concerning age differences, neither line-up type appears to help children or older adults to reduce their choosing bias (Fitzgerald & Price, 2015). There have, however, been many attempts to increase the probability of a child making a correct target absent rejection instead of an erroneous identification, with some positive findings, such as the introduction of a *wildcard* (i.e., a silhouette of a person), or an *elimination round* (i.e., where the task is to eliminate line-up members until only one remains) (Pozzulo & Lindsay, 1999; Pozzulo, Reed, Pettalia, & Dempsey, 2016; Sheahan, Pica, Pozzulo, & Nastasa, 2017; Zajac & Karageorge, 2009). As regards adolescents, little is known, and with reference to older adults, although their

choosing patterns are similar to children, little research has focused on reducing their choosing bias (Fitzgerald & Price, 2015)

Concerning the potential interactive effects of line-up type with distance or lighting, there is no existing literature, and therefore no investigation of the combined (and interactive) effects of distance, lighting, age, and line-up type. When considering distance (and lighting) as a proxy for facial encoding strength, the lack of research on weak vs strong memory encoding combined with eyewitness age and line-up types is of concern. In real life scenarios, facial encoding can, nevertheless, be influenced by many factors other than distance or light, such as, the weapon focus effect (Erickson, Lampinen, & Leding, 2014; Fawcett, Russell, Peace, & Christie, 2013).

For the present thesis, we investigated how strong versus weak facial encoding (i.e., observations made at distances between 5 and 110 meters) interacted with age and line-up type on target present and target absent line-up accuracy (Study I). In Study II, we were only able to investigate the combined effects of distance and lighting on identification accuracy in target present simultaneous line-ups. However, in Study III we also investigated the effects of line-up position on selections (see the following chapter) in sequential and simultaneous line-ups, where we expected facial encoding strength (i.e., distance), age, and line-up type to give rise to important differences.

## **1.6 Line-up Position Effects**

As photograph line-ups consist of a certain number of images displayed either sequentially or simultaneously, there are questions regarding how eyewitnesses make decisions and if the line-up array itself influences choices. Specifically, do certain positions, such as, the first image in sequential line-ups or the top row in simultaneous line-ups receive more attention and more selections compared with other positions? Unfortunately, there appears to have been little consensus on how to systematically investigate position effects (cf. Memon & Gabbert, 2003), and overall, studies either neglect to discuss position effects or mention very few details or none at all; making comparisons very difficult.

In sequential line-ups, research shows that if the next-best filler (i.e., the line-up member that most resembles the perpetrator) is placed before the perpetrator in the line-up, then it reduces the chances of a correct identification of the target (Clark & Davey, 2005). There is also some evidence that (adult) eyewitnesses are less inclined to choose the first image or position in a line-up and become more liberal towards the final images (Meisters, Diedenhofen, & Musch, 2018). Interestingly, this shift from a conservative to a more liberal decision strategy has sometimes been found to only occur when eyewitnesses know how many images will be displayed in the line-up (Carlson, Carlson, Weatherford, Tucker, & Bednarz, 2016; Horry, Palmer, & Brewer, 2012). Other studies have found similar effects where the eyewitnesses were unaware of the number of images to be shown (Carlson et al., 2016; Masters et al., 2018). Nonetheless, there appears to have been little systematic investigation of position

effects in sequential line-ups and there is also an ongoing debate on how to appraise line-up position effects in sequential line-ups (Wilson, Donnelly, Christenfeld, & Wixted, 2019).

Considering that children and older adults show stronger reliance on familiarity, and that at least children and to a certain extent adolescents show higher disinhibition (Fitzgerald & Price, 2015; Nigg, 2000), it is likely that sequential line-ups affect the choosing bias differently depending on the age of the eyewitness. Reliance on familiarity and disinhibition could lead to a first position choosing bias in sequential line-ups, because the first image presented is sufficiently familiar and it is difficult to inhibit a selection. This may also be the case for older adults who have also been shown to rely on familiarity (e.g., Fitzgerald & Price, 2015), although deficits in inhibition are less clear in older adults (Rey-Mermet & Gade, 2018). Earlier research has not investigated these age differences in position effects.

In simultaneous line-ups, studies have found edge-version bias (i.e., not selecting from the edge positions) (O'Connell & Synnott, 2009), bottom row bias (Sporer, 1993), or top row bias (Carlson et al., 2019; Palmer, Sauer, & Holt, 2017). However, other results have found no such biases (Clark & Davey, 2005; Meisters et al., 2018). Eye tracking studies do, nevertheless, show that eyewitnesses do not look at all positions equally, implying that there are differences in how much attention is given to each position (Mansour, Lindsay, Brewer, & Munhall, 2009).

In the present thesis, we were interested in the effects of facial encoding strength in relation to age and the effects of line-up position. Based on disinhibition found in children and adolescents, we hypothesized that they would show a tendency towards selecting the first image presented in sequential line-ups. We also assumed that the reliance on familiarity shown by older adults would increase the likelihood of this age group selecting the first position in sequential line-ups. We were also interested in possible position effects (i.e., a top row preferences) in simultaneous line-ups, but our main interest was to investigate sequential line-up position selections.

## **1.7 Eyewitness Accuracy Postdiction: Confidence & Response Time**

In eyewitness research, it has been found that confidence ratings of line-up choices, which are given after the choice, are to some extent associated with accuracy, so that when confidence is high, it is more likely that the line-up decision was accurate (Sporer, Penrod, Read, & Cutler, 1995; Wixted & Wells, 2017). High confidence has generally been operationalized as a 90–100% confidence and the association has led to the suggestion that post line-up confidence can be used as a relatively reliable postdictive method of evaluating the accuracy of an eyewitness line-up identification (Wixted & Wells, 2017). Moreover, researchers have argued that under pristine conditions (i.e., when best evidence-based police procedures are used: best system variables) then estimator variables, such as distance, are

unimportant factors because high confidence consistently postdicts identification accuracy (Semmler, Mickes, Dunn, & Wixted, 2018). A confidence accuracy characteristic (CAC) analysis (Mickes, 2015) provides a measure of the relationship between an eyewitness's identification accuracy and their confidence rating. If their confidence is well calibrated, a high confidence rating will indicate that they have been able to discriminate between the actual perpetrator and an innocent filler. However, recent studies suggest that the relationship is imperfect and that the relationship is weaker when facial recognition ability is poorer, when decision times are longer (i.e., slower), or when eyewitnesses base their decisions on familiarity (Grabman, Dobolyi, Berelovich, & Dodson, 2019). Moreover, studies show that eyewitness age may be an important moderator of the confidence accuracy relationship, because both older eyewitnesses (Martschuk, Sporer, & Sauerland, 2019) and young children (Brackmann, Sauerland, & Otgaar, 2019) have been found to be less well-calibrated eyewitnesses compared with young adults.

As with the confidence accuracy relationship, there has also been research on the response duration, where shorter (i.e., fast) responses have sometimes been found to be more accurate compared with longer (i.e., slower) response times. Early studies suggested that responses below 10–12 seconds are associated with higher accuracy in simultaneous line-up (Dunning & Perretta, 2002). However, although previous research provides evidence that shorter response times are associated with identification accuracy, findings have varied too much to establish a clear cut-off, such as above or below 10–12 seconds, for use in the field (Brewer, Caon, Todd, & Weber, 2006; Weber, Brewer, Wells, Semmler, & Keast, 2004). More recent studies echo the findings that shorter response times are associated with identification accuracy in simultaneous line-ups (Seale-Carlisle et al., 2019). In sequential line-ups, investigating the association is more complicated due to line-up images being presented one after another. However, evidence suggests that response times in these line-ups may vary to an extent where the response time is not clearly associated with identification accuracy (Sauer, Brewer, & Wells, 2008).

In the present thesis, we looked at the postdictive value of confidence and response times in both Study I (distances between 5 and 110 meters) and Study II (distances between 6 and 20 meters and three lighting conditions: 0.7 lux, 10 lux, and 300 lux). These two studies represent a new attempt to investigate the postdictive value of confidence and response times under suboptimal viewing conditions with a large sample size providing adequate statistical power. Our aim was to shed light on the relationship between accuracy and these postdictive measures by assessing whether their association with accuracy held true when visual facial encoding was weaker.

## **1.8 The Accuracy of Eyewitness Descriptions and Estimations**

Archival studies on actual witnesses' descriptions of perpetrators show that the average number of reported details is low (approximately 7–9 features) and the quality and accuracy of the descriptions (measured as falling within a specific range or

matching specific features) vary depending on the described feature (Meissner, Sporer, & Schooler, 2007). For example, witnesses have been found to give relatively accurate descriptions (with an error rate of approximately 20%) of general features, such as, gender, age, height, weight, build, and hair color (Kuehn, 1974; Yuille & Cutshall, 1986). However, witnesses also tend to give vague descriptions such as “average height” or describe the clothes worn by the perpetrators, which may be of little use when trying to identify and apprehend a perpetrator (Meissner, Sporer, & Schooler, 2007; Sporer, 1992). Higher degrees of accuracy have been found in laboratory-based studies compared to real life situations, although more comparisons are needed. In both cases, descriptions tend to be vague with few details (~10%) relating to facial features (Lindsay, Martin, & Webbert, 1992).

Research shows that, compared with young adults, young children and older adults give less accurate descriptions (Meissner, Sporer, & Schooler, 2007); although the differences have not always been significant (Jack, Leov, & Zajac, 2014; Karageorge & Zajac, 2011; Sheahan et al., 2017). As with identification accuracy, the lower descriptive accuracy is believed to be associated with cognitive development in the case of young children and visual and memory-based decline in older adults (Meissner, Sporer, & Schooler, 2007). Moreover, describing a perpetrator’s characteristics (e.g., gender, age, weight, and height) demands a certain level of cognitive maturity and experience or education in using scale measurements (e.g., kilograms, centimeters), which most likely impacts children’s accuracy (e.g., Pozzulo & Warren, 2003). Although estimation accuracy (based on numerical estimates) is not equal to descriptive accuracy (based on verbal descriptions), the concepts are closely related. This is because it is unlikely that an eyewitness could give an accurate and useful verbal description of a perpetrator to the police but simultaneously be unable to give relatively accurate estimates of the perpetrator’s gender, age, height, and weight.

Increased distance has not been found to influence age estimation accuracy in a clear manner, but height and weight estimates become less accurate, while there is no clear evidence regarding at which point increased distance leads to mistakes in gender estimation (Lindsay et al., 2008; Meissner, Sporer, & Schooler, 2007). To date, there has been no eyewitness research into the effects of lighting on descriptive or estimation accuracy or the combined effects of distance, lighting, and age on descriptive or estimation accuracy. Our aim was to investigate estimation accuracy at long distances, because although identification accuracy may be limited by a lower visual identification threshold for reliable eyewitness identification, estimations could potentially be informative even up to a greater distance.

## 2 Aims, Hypotheses, and Research Questions

In the present thesis and associated publications, we were interested in the upper visual distance threshold of reliable eyewitness identification moderated by line-up type and eyewitness age (Study I). We were also interested in the combined effects of viewing distance and lighting on target present line-up accuracy (Study II), the effects of viewing distance, eyewitness age, line-up type, and line-up position on line-up selection patterns (Study III), and the effects of viewing distance and eyewitness age on target estimation accuracy (Study IV).

**Study I.** As visual perception is negatively affected by increased distance, we investigated the threshold at which the viewing distance to a live person is so great that an observation followed by a reliable identification is highly unlikely. We also investigated whether this visual threshold is moderated by eyewitness age and line-up type. Our hypotheses were that there would be an interactive effect between distance and age on identification accuracy, so that increased distance would have a more negative effect on the accuracy of young children (6–11) and older adults (45–77) compared with young adults (18–44). We also investigated the differences between sequential and simultaneous line-ups due to an ongoing debate on the superiority of either line-up type, and due to the lack of research on the interactive effects between viewing distance, eyewitness age, and line-up type. Here, we investigated identification accuracy by presenting participants with live targets, immediately followed by target present or target absent sequential or simultaneous line-ups. Lastly, we looked at confidence and response time as postdictive measures of identification accuracy moderated by memory strength (i.e., viewing distance).

**Study II.** As visual perception is negatively affected by both increased distance and decreased lighting, we investigated the threshold at which viewing distance and lighting conditions are so poor that an observation followed by a reliable target present line-up identification is highly unlikely. Our hypotheses were that the combined effects of lighting and distance would result in an upper distance threshold that would be much lower than the one found under pristine viewing conditions (Study I). Here, we investigated identification accuracy by presenting participants with live targets, immediately followed by forced choice, simultaneous, target present line-ups. We also investigate the association between identification accuracy and confidence and response time.

**Study III.** Based on the same data set as Study I, we investigated line-up position effects on eyewitness selection patterns. More specifically, we investigated whether individuals tended to favor certain positions in either sequential or simultaneous line-ups. Our hypotheses were that children (6–17), due to disinhibition, and the oldest adults (59–77), due memory deficits, would be more prone to selecting the first image presented in a sequential line-up compared with young adults (18–44). In addition, that as viewing distance increased (i.e., as facial encoding strength weakened), all age groups would show an increased tendency to select the first image presented in a

sequential line-up due to adopting a more liberal response criterion. In simultaneous line-ups we expected to find a top row selection preference.

**Study IV.** Based on the same data set as Study I, we investigated the effects of increased viewing distance and eyewitness age on target estimation accuracy. Our hypotheses were that overall accuracy would be low and that young children (6–11), older children (12–17), and older adults (45–77) would be less accurate compared with young adults (18–44).



## 3 Methods

### 3.1 Participants

Studies I, III, and IV were based on the same data collection, while Study II was based on a separate data collection. An overview of the samples is presented in Table 1.

Table 1

*Distribution of Participants by Study, Age, and Gender*

Study	Age	<i>N</i>	<i>M</i> <sub>age</sub>	SD	Female	Male	Other
I, III, IV	6–77	1588	29.25	17.13	961	588	39
II	19–51	178	24.45	6.4	129	47	2

The participants in Studies I, III, and IV were recruited at the Finnish Science Centre Heureka in Helsinki, which is run by the Finnish Science Centre Foundation and is a non-profit organization aimed at popularizing and communicating scientific endeavors to the general public. All participants recruited the Finnish Science Centre Heureka received comprehensive information about the experimental design prior to participation and did not receive compensation for taking part in the experiment. Participants who were younger than 12 years of age were only admitted to the experiment if a close relative was present who could give consent for them to participate, as well as the child giving their own assent. Participants in Study II were recruited at the Åbo Akademi University campus either in person or via emails and pamphlets. All participants in Study II received a free lunch voucher for use at the university canteen as compensation for their participation.

#### 3.1.1 Age Groups

In the current thesis and associated studies, we were interested in age differences in eyewitness reliability. For this reason, we categorized age into separate groups prior to our analyses in Studies I, III, and IV. The sample in Study II was too small and the age range of the participants was too narrow for us to use this same approach. The age categorization in Studies I and IV is identical, whereas in Study III an additional age categorization was used to enable the exploration of all our hypotheses. An overview of the age categorizations is presented in Table 2.

Table 2

*Distribution of Participants in Studies I, III, and IV by Age group, and Gender*

Study	Age group	<i>n</i>	<i>Mean</i>	<i>SD</i>	Women	Men	Other
I, III-IV	Young Children (6–11)	266	9.31	1.45	147	112	7
I, III-IV	Older Children (12–17)	311	13.71	1.61	184	121	6
I, III-IV	Young Adults (18–44)	690	31.95	7.49	436	237	17
I & IV	Older Adults (45–77)*	321	55.03	9.08	194	118	9
III	Older Adults (45–59)*	225	49.88	3.96	136	88	1
III	Oldest Adults (60–77)*	96	67.13	5.48	58	30	8

*Note.* \*In Study III age group "Older Adults (45–77)" was re-categorized to two new age groups: 1) "Older Adults (45–59)", 2) "Oldest Adults (60–77)".

## 3.2 Ethics Statement

Prior to the data collections, Studies I, III, and IV received ethical approval from the Ethical Committee of Åbo Akademi University, and Study II received ethical approval from the Ethical Committee at the Department of Psychology and Logopedics of Åbo Akademi University.

## 3.3 Procedures, Measures, and Statistical Analyses

### 3.3.1 Studies I, III, and IV

**Outline.** The Heureka data collection, on which Studies I, III, and IV were based, was an experimental design where we, in an outdoor setting, presented groups of 1–4 participants with four live targets (i.e., people to be observed), one at a time, at distances between 5 and 110 meters. All answers (i.e., participant demographics and line-up task questions) were collected on 10.1-inch computer tablets, that were attached to a table via a flexible holder. Each participant had a tablet in front of them and there were screens in-between participants to shield the view of each other's tablets. For an illustration of the point of view of the participant, please see Figure 1, which is an image from the 110-meter-long path that we built at the Finnish Science Centre Heureka and where targets were presented; albeit in Figure 1 there is no target present.



*Figure 1.* Photograph of the point of view of our participants during the Heureka data collection.

**Distances.** During the experiment, targets were presented at one of 16 possible distances. Each distance was chosen from a randomized list. The distances were placed at intervals of five meters between 5 and 50 meters and at intervals of 10 meters between 50 and 110 meters. This was done in order to gain more fine-grained information at smaller distances and less detailed at greater distances, where we assumed that the ability to distinguish and encode distinct facial features would rapidly decline. The distances were also block randomized, so that each participant group would view targets at similar degrees of difficulty: albeit in a randomized order. We used the following distance blocks: 1) 5–20 meters, 2) 25–40 meters, 3) 45–70 meters, 4) 80–110 meters.

**Lighting.** Although we did not manipulate the lighting, we did measure the lighting conditions. We did this approximately once every hour. The experiment was conducted during daylight hours in the summer, during which time there was roughly 17–18.5h of sunlight per day. Based on our measurements, the average lighting conditions were 43139 lx ( $SD = 33452$ , min = 4005 lux, max = 99999 lux), implying that our eyewitnesses observed our targets under optimal lighting conditions.

**Line-ups.** During the experiment, participants took part in a line-up task (see procedure below). The line-ups were manipulated between participants so that each participant saw all four line-ups as either sequential or simultaneous line-ups; consisting of eight images. In sequential line-ups images were presented one by one in sequential order and in simultaneous line-ups images were presented in two rows of four images on the same page. Image size was kept constant between line-up types and all image positions were randomized. We also manipulated the line-ups so that the target was either present or absent in the line-up; this manipulation was balanced across all targets, meaning that a participant could receive any combination of target absent and target present line-ups. Each line-up also contained the possibility of rejecting the line-up. To evaluate our line-ups, we ran a post line-up test by showing target present or absent simultaneous line-ups to 49 participants and asked them to select the image that best fitted a list of attributes (the same used to select fillers when constructing the line-ups). We were unable to calculate the functional size of the first line-up because no one selected the target. The functional size of line-up 2 was 1.4, of line-up 3 was 2.08, and of line-up 4 was 6.33. Due to the limitations of this evaluation, we also included the target as a random factor in our main analyses, thus averaging the results over the line-ups and balancing out any bias towards or against the different targets.

**Procedure and measures.** Each participant or group of participants began by reading an information placard that had been placed outside the experimental enclosure (i.e., outside the view that is displayed in Figure 1). Inside the enclosure, a test instructor repeated the information stated on the placard outside. Once verbal consent was given to the test instructor, each participant then placed themselves in front of their designated tablet and then the experiment began. The procedure and measures that followed is outlined step by step in Table 3.

Table 3

*Procedure of Studies I, III, and IV*

Step	Task	Task Description & Measures
1	Language	Select language (Finnish, Swedish, English).
2	Consent	Agree to participate (yes or no). Participated before (yes or no).
3	Demographics	Fill in own gender, age, height, nationality.
4	Eye test	A tablet-based visual acuity test.
5	Practice round	The test instructor verbally guided the participants through a mock trial on the tablets.
6	View live target	A target was presented on the pathway for 20 s. while rotating their head from side to side. Response times were recorded by the tablet.
7	Estimation of the target	Participants estimated (using visual sliders) the target's gender (man or woman), age (5–99), height (0–220 cm), weight (0–150 kg), and the viewing distance to the target (0–200 meters).
8	The line-up task	Participants were presented with a line-up task. A sequential or simultaneous target present or absent line-up.
8	Post line-up questions	Participants estimated their line-up choice confidence (0–100%) and if they recognized any line-up photos prior to the experiment.
9	Trials 2–4	Steps 6–8 were repeated in order to show targets 2–4.
10	Feedback	Participants received result feedback

**Statistical analyses.** Prior to the main analyses, we removed errors due to human mistakes and technical faults.

In Study I, for our main analyses we used multilevel logistic regressions to investigate the effects of age group, distance, and line-up type on the likelihood of identification and rejection accuracy. We also combined these results in order to calculate line-up diagnosticity and sensitivity or memory strength (i.e.,  $d'$ ) per line-up and age group. Furthermore, in order to investigate the effects of response time, we added response time as a factor in our regression analysis, and to investigate confidence we conducted a separate confidence accuracy characteristic (CAC) analysis (Mickes, 2015). ANOVA-type analyses and post hoc comparisons were also conducted to verify and expand upon the initial findings.

In Study III, we investigated line-up position effects in sequential line-ups by dichotomizing the eight positions to 1st versus 2–8th and in simultaneous line-ups by dichotomizing the eight positions to top versus bottom row. We then used multilevel logistic regressions to investigate if distance, age, and positions affected eyewitness selection patterns. Next, using the same statistical methods, we analyzed if distance, age, and positions affected the likelihood of making a correct target present identification and the likelihood of making an incorrect innocent suspect identification in target absent line-ups. ANOVA-type analyses and post hoc comparisons were used to establish main effects, interactions, and comparisons.

In Study IV, for our main analyses, we used a method borrowed from earlier research (Lindsay et al., 2008), where we categorized estimation accuracy as within either +/- 2 units, +/- 5 units, +/- 10, or more than +/- 10 units of error (i.e., “serious errors”). Gender mistakes were also categorized as serious errors. We then first approached the question of estimation accuracy by running multilevel logistic regressions on the likelihood of being accurate within +/- 2 units for age, height, and weight estimates or correctly estimating gender. Here, the predictors were distance and age. Next, we used the same method to investigate the likelihood of a serious error (i.e., +/- 10 units or incorrectly estimating gender). Using the same statistical approach, we also investigated own age and own height anchoring biases in estimating the age and the height of the targets observed. Lastly, we investigated the association between estimation errors. Main effects and interactions were inspected through ANOVA-type analyses and post hoc comparisons.

### 3.3.2 Study II

**Outline.** Study II was an experimental design where we, in an indoor setting, presented 1–2 participants with eight live targets, one at a time, at distances between 6 and 20 meters in one of three possible lighting settings (0.7 lux, 10 lux, or 300 lux). All answers were collected on hand-held 10.1-inch computer tablets. For an illustration of the point of view of the participant, please see Figure 2, which is an image from the 20-meter-long path that was used in the experiment.



*Figure 2.* Photograph of the point of view of our participants during the data collection of Study II. The current view is approximately 6 meters from the position where the targets were presented (at the far end of the corridor).

**Distances.** During the experiment, all targets were presented in the same position (i.e., at the end of the corridor illustrated in Figure 2) while participants were instructed (by the test instructor) to change positions in the corridor between trials. There were eight possible distances ranging from 6–20 meters; with 2-meter intervals. All participants saw one target at each distance.

**Lighting.** As depicted in Figure 2, we had placed movable LED light fixtures at the end of the corridor to illuminate the faces of our targets, while we kept the rest of the corridor dark. We created three lighting conditions: 1) low lighting (i.e., moonlight conditions; 0.7 lux), 2) medium lighting (i.e., twilight conditions; 10 lux), 3) high lighting (i.e., office space conditions; 300 lx). The lighting conditions were defined by the amount of lighting (i.e., measured lux) that reached the face of the target; that is, the light source was facing toward the target. One lighting condition was set up for a whole day and all participants recruited that day took part in that lighting condition. We rotated the lighting conditions per experiment day. In each lighting condition, participants saw eight live targets, each at a separate viewing distance.

**Procedure and measures.** Each participant or group of participants were first met in the main aula of the university campus where they received a verbal description of the experiment, following which they began the procedure outlined in Table 4.

**Line-ups.** During the experiment, participants took part in a line-up task (see procedure below). The line-ups were forced choice (i.e., no possibility of rejecting the line-up) target present eight-person simultaneous line-ups. Each line-up consisted of two rows of four images. Line-up image positions were randomized. We evaluated the line-ups by presenting target present simultaneous line-ups to 49 participants and found that five of our line-ups were biased towards the target, two towards the fillers, and one not biased. The results were not clear-cut because we did not include target absent line-ups, there was no time limit meaning that small variations between line-up members played a role (e.g., eye color could clearly be discerned). However, as in Study I, we included the target as a random factor in our model, this balanced out any biases statistically.

**Statistical analyses.** Prior to the main analyses, we removed errors due to human mistakes and technical faults. In Study II, we investigated the likelihood of a correct or incorrect identification by using a multilevel logistic regression where the outcome was correct or incorrect identification and the predictors were distance and lighting. We investigated the main effects and interactions through ANOVA-type analyses and post hoc comparisons. We investigated confidence and response time by categorizing confidence into two groups (0–80% and 81–100%), response time into three groups (0–10 s, 11–15 s, and more than 15 s), and distance into two groups (6–12 m and 14–50 m). We then ran separate analyses where the accuracy was the outcome variable and distance, lighting, and either the re-categorized groups of confidence or response time were the predictors. We also re-ran the same models where we treated distance, confidence, and response times as continuous variables.



Table 4

*Procedure of Study II*

Step	Task	Task Description & measures
1	Informed consent	Comprehensive information about the experiment
2	Demographics	Fill in own gender, age, occupation, nationality, and the nationality of people with whom you have grown up with, Corrected or uncorrected eyesight (yes or no; how much)
3	Eye test	A tablet-based visual acuity test.
4	Practice round	The test instructor verbally guided the participants through a mock trial on the tablets.
5	View live target	A target was presented on the pathway for 20–30 seconds while rotating their head from side to side.
6	The line-up task	Participants were presented with a forced-choice simultaneous target present line-up task. Response times were recorded by the tablet.
7	Post line-up questions	Participants estimated the age of the target (free text), their line-up choice confidence (0–100%: 10-point increments), viewing distance to the target (1–26 m: 2-m increments). They also answered if they recognized any of the line-up photos prior to the experiment (yes or no).
8	Trials 2–8	Steps 5–7 were repeated in order to show targets 2–8.
9	Feedback	Participants received result feedback.

## 4 Results

### 4.1 Study I

**Main results.** When investigating the effects of viewing distance and eyewitness age on target present identification accuracy and target absent rejection accuracy, we found a dramatic negative effect of increased distance on accuracy. Furthermore, we found that young children and older adults were less accurate compared with young adults (see Figure 3 & 4). These findings were similar in both sequential and simultaneous line-ups, albeit the simultaneous line-ups gave rise to higher degrees of target present identification accuracy. Notably, considering our investigation of an upper distance threshold, we found that longer viewing distance did not decrease the likelihood of making a misidentification (i.e., selecting a so called “innocent suspect”; see Figure 4 Panels A and B). However, the likelihood of a correct identification (i.e., selecting the so called “perpetrator”; see Figure 3 Panels A and B), did decrease. At 40 meters, line-up diagnosticity (i.e., information gain) was approximately 50% lower than at 5 meters, and by 100 meters diagnosticity was 1 (+/- 0.5) for all age groups. Moreover, as can be seen in Figure 3, target present identification and target absent rejection accuracy was already very low between 5 and 10 meters. This suggests that accuracy was low due to participant encoding problems more than memory-related problems (although memory-related problems cannot be ruled out entirely), particularly in light of the fact that the identification task was completed immediately after viewing the target.

**Additional results.** When investigating the postdictive value of confidence and response time, we found that high confidence (i.e., 81–100%) was postdictive of correct identifications (i.e., of making a correct target present identification rather versus making an innocent selection in target absent line-ups) up to approximately 40 meters, after which there were very few high confidence decisions (both correct and incorrect). Our CAC analyses confirmed that high confidence was associated with identification accuracy, but only up to 40 meters. Response time was also associated with identification accuracy so that the shorter the response time, the more accurate the witness. We had categorized response time into four groups: 0–5 s, 5–10 s, 10–15 s, and 15 s or more. The shortest response group was the most accurate, and the trend followed a linear decline with longer response times being associated with more incorrect responses. We also found that distance estimation accuracy was overall inaccurate and that error rates increased with increased distance.

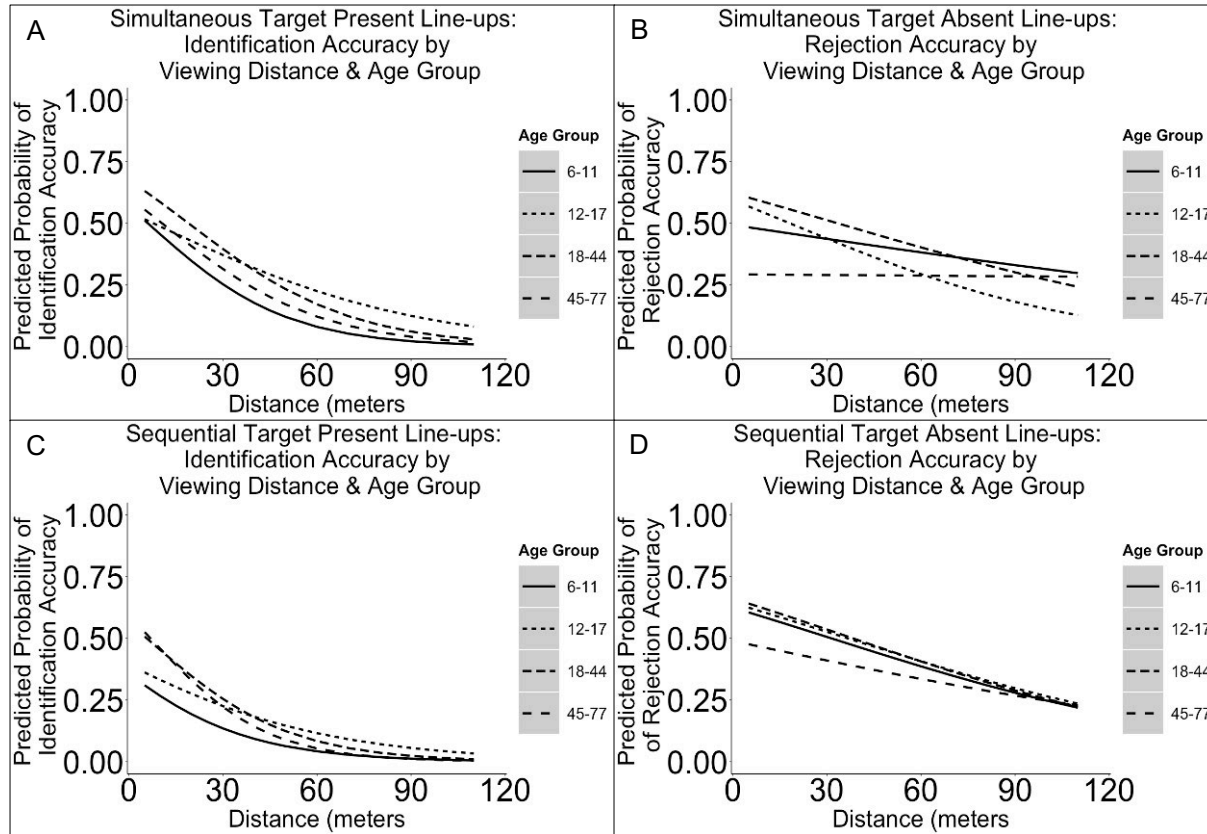


Figure 3. Panels A and B illustrate identification accuracy by age group and distance in target present simultaneous and sequential line-ups, while panels C and D represent the same for rejection accuracy.

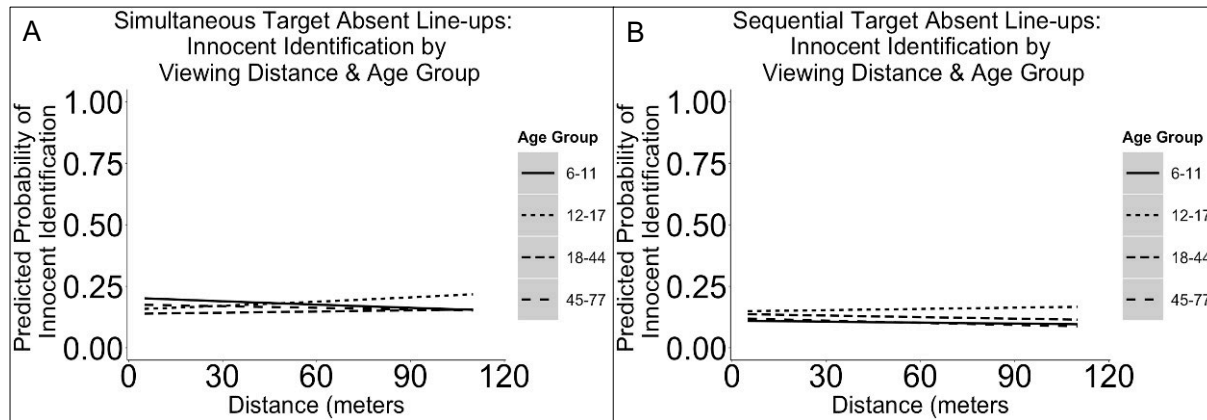


Figure 4. Panels E and F illustrate the likelihood of incorrectly identifying an innocent suspect by age group and distance in target absent simultaneous and sequential line-ups. The innocent suspect was defined as the four most selected images in the data set. That is, we looked at the frequencies of most selected fillers (per line-up) in target absent and target present line-ups and then defined these our four innocent suspects.

## 4.2 Study II

**Main results.** Investigating the effect of distance and lighting on identification accuracy in target present simultaneous line-ups, we found a dramatic decrease in accuracy due to increased distance and due to lower lighting (see Figure 5). As illustrated in Figure 5, there was an almost linear negative effect of increased distance on accuracy, while each level of lower lighting resulted in a dramatic overall decrease in accuracy. We found no interactive effects between distance and lighting. It is of importance that at 20 meters in the low lux condition (i.e., 0.7 lux), identification accuracy was at chance level (i.e., the likelihood of selecting a target in the line-up was the same as if the eyewitness was making a choice blindfolded).

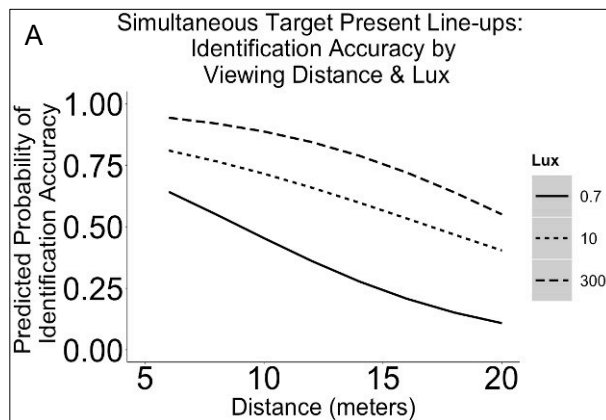


Figure 5. An illustration of identification accuracy by lux and distance in target present simultaneous line-ups.

**Additional results.** Investigating the postdictive value of confidence and response time in target present line-ups, we found that high confidence (i.e., 81–100%) was more predictive of an accurate identification compared with low confidence (0–80%) in all three lighting conditions and at both shorter and longer distances. We had categorized response time into three groups: 0–10s, 10–15s, and 15s or more, and found that a shorter or quicker response time was more likely to result in a correct identification compared with longer response times.

## 4.3 Study III

**Main results.** In Study III, our main focus was the interactive effects of line-up position, viewing distance, and age group on selection patterns in either sequential or simultaneous target present or absent line-ups. We found a main effect of distance illustrating an overall increase in first line-up position selections as the viewing distance increased (see Figure 6). In target present line-ups, at smaller distances (i.e., 5–20m) there was no difference between

first line-up position selections and line-up positions 2–8, but at greater distances (80–110m) the likelihood of a first position selection was higher. Young children (but no other age group) were more likely to select from the first line-up position compared with young adults. In target absent line-ups, the likelihood of selections was higher in the first line-up position compared with line-up positions 2–8. Compared with young adults, all age groups except older adults (45–59) were more likely to select from the first position. Moreover, looking at the combined data from target present and target absent line-ups, a CAC analysis revealed that high confidence (91–100%) was calibrated with accuracy in line-up positions 2–8 for all age groups, but in the first line-up position, young children and the oldest adults made more erroneous high confidence decisions (i.e., they were not as well calibrated). We also found some tendency to select from the top row in simultaneous line-ups, but the effects were moderated by both age group and distance.

**Additional results.** We also investigated the effect of distance, age, and line-up position selections on the likelihood of a target present identification accuracy and target absent innocent identifications. As the effects of distance and age had already been investigated in Study I, we were interested here in the added impact of line-up position selections. In target present sequential line-ups, we found that first position selections were less likely to lead to a correct identification (compared with positions 2–8). In target absent line-ups, first positions selections did not impact the likelihood of an innocent selection. The results from the simultaneous line-ups showed that the slight top row selection preference also resulted in a slightly elevated likelihood of target present identifications and target absent innocent identifications in the top row.

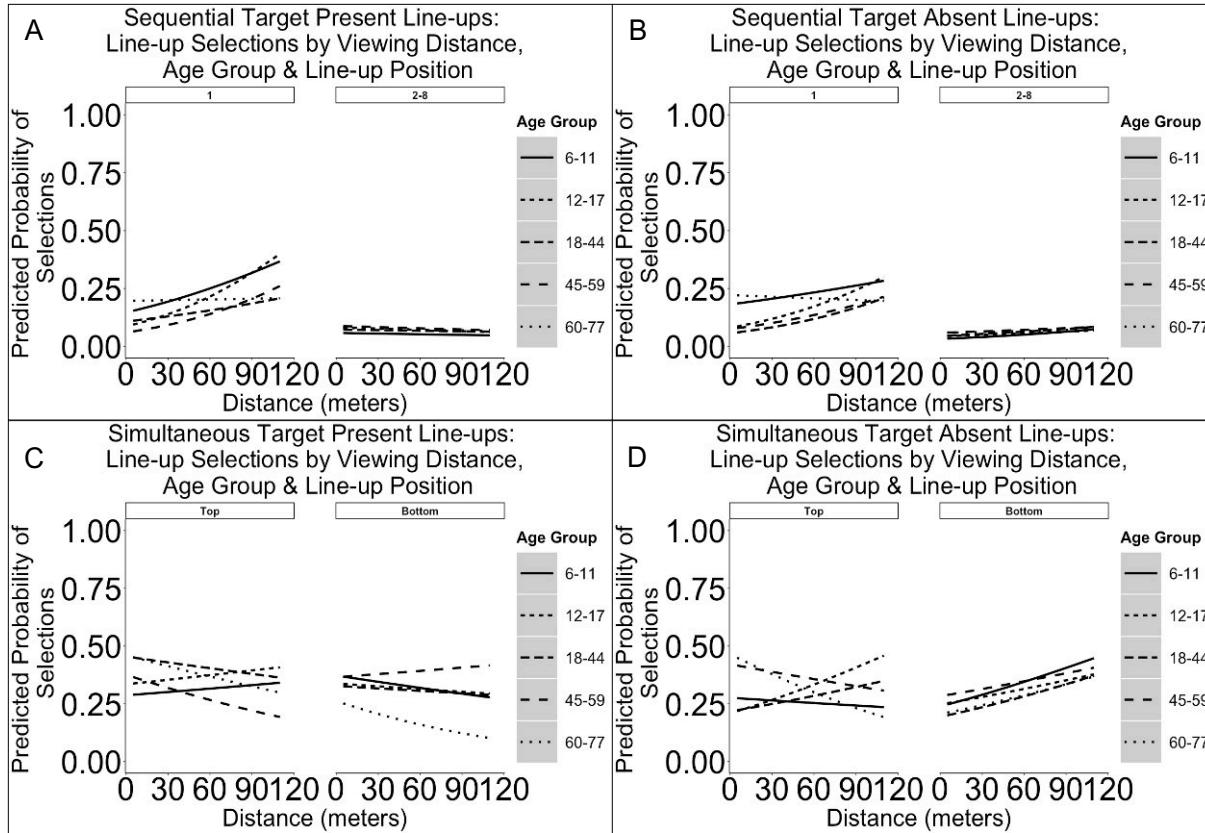


Figure 6. Panels A and B illustrate line-up position selections by distance, age group and position, in target present and absent sequential line-ups, while panels C and D represent the same for simultaneous line-ups.

## 4.4 Study IV

**Main results.** When investigating the effects of viewing distance and eyewitness age on the accuracy of target estimations, we found that the likelihood of accurate gender estimation was high, while high estimation accuracy ( $\pm 2$  units of the actual value) of age, height, weight was low (see Figure 7). Increased distance led to a decline in high estimation accuracy for gender, age, and height estimation but not weight estimation, and especially young children performed worse compared with young adults (see Figure 7). When investigating the likelihood of making a serious estimation errors (i.e., more than  $\pm 10$  units) due to distance and age, the effects were a close mirror image of the effects found for high accuracy (see Figure 8). That is, the likelihood of errors increased slightly with increased distance; with clear differences between age groups (see Figure 8). This means that the likelihood of being highly accurate diminished with increased distance while at the same time the likelihood of making serious errors in estimations increased.



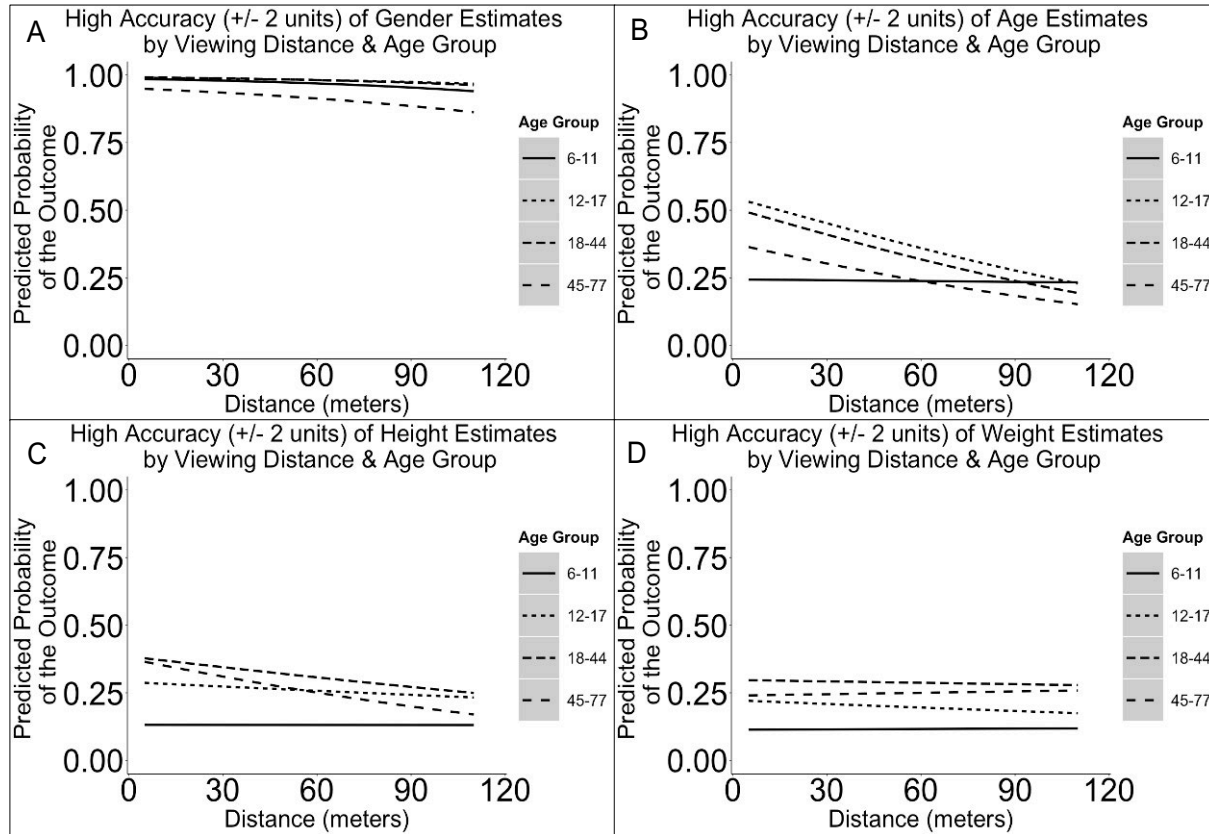


Figure 7. The four panels represent high accuracy of estimations of gender (Panel A), age (Panel B), height (Panel C), and weight (Panel D) by age group and distance.

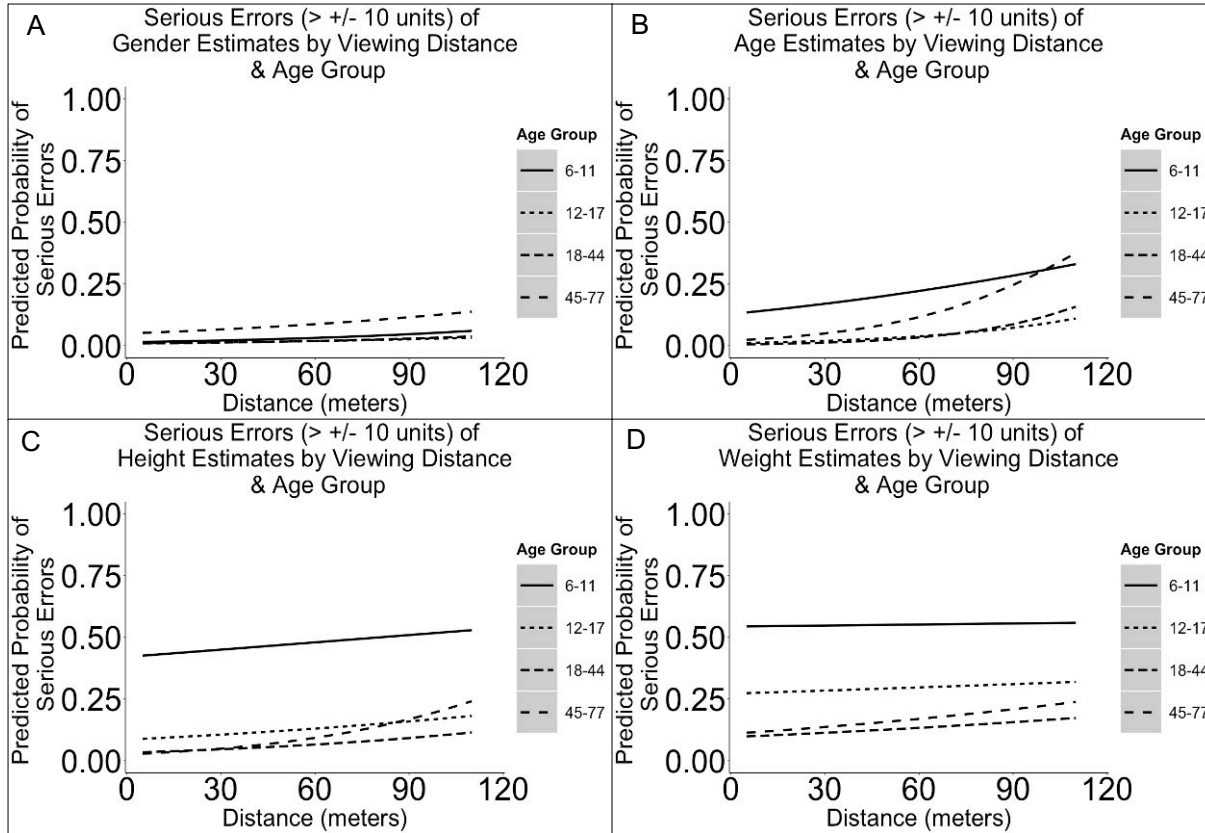


Figure 8. The four panels represent serious errors of estimations of gender (Panel A), age (Panel B), height (Panel C), and weight (Panel D) by age group and distance.

## 5 Discussion

The overarching goal of the present thesis and associated studies was to investigate the effects of viewing distance, lighting, eyewitness age, line-up type, and position effects on eyewitness accuracy using live targets and actual distances and lighting conditions. More specifically, we were interested in identifying the visual thresholds after which an eyewitness observation and later correct identification is extremely unlikely, and how this threshold is moderated by eyewitness age, line-up type, and line-up position. As we manipulated distance and lighting, which can be seen as proxies for visual facial encoding strength, we also had the unique opportunity of investigating the effects of memory strength on confidence and response time as postdictive measures of identification accuracy in a large dataset. Combined, our samples include over 1750 participants and over 7500 eyewitness line-up decisions. Moreover, the Heureka data collection on which Studies I, III, and IV are based, is to the best of our knowledge, the largest live eyewitness experiment to have been conducted and includes the largest age range ever investigated in an experimental eyewitness study. These two distinguishing features add to the generalizability of our research.

### 5.1 Interpreting the Results

#### 5.1.1 Study I: The Effects of Distance, Age, and Line-up Types

The results from Study I correspond with earlier findings that young children and older adults are less accurate compared with young adults (Erickson et al., 2015; Fitzgerald & Price, 2015; Pozzulo & Lindsay, 1998). As expected, our investigation of increased distance is also in line with earlier findings that increased distance decreases accuracy (Jong et al., 2005; Lampinen et al., 2014, 2015; Lindsay et al., 2008; Loftus & Harley, 2005; Wagenaar & Van Der Schrier, 1996). Moreover, as we investigated the combined effect of distance and age on eyewitness accuracy, we also found that increased distance had a relatively similar effect on all age groups. This resulted in an absolute upper distance threshold of 100 meters being applicable overall. However, young children and older adults were less accurate at the shortest distance (i.e., 5 meters) and their upper distance thresholds were also lower (approximately 10–20 meters) compared with young adults (and older children). It is also important to note that target present and target absent accuracy was already rather low, approximately 50%, at 5–10 meters and decreased to approximately 30% at 40 meters.

In practice, these findings imply that eyewitness identifications made after having seen a perpetrator at a distance of more than 40 meters should not be considered particularly reliable as evidence. However, this is a result based on optimal viewing conditions, which is most likely not the case in a real-life scenario indicating that reliability will be even lower than we have estimated at 40 meters. We also found that target present identification accuracy was higher in simultaneous as compared to sequential line-ups, but that increased distance had a similar negative effect on

accuracy in both types of line-ups for all age groups. These findings on line-up differences are difficult to interpret in terms of the debate regarding which line-up is superior (e.g., Wells, Steblay, & Dysart, 2015), because no earlier publication has compared the interactive effects of distance and line-up type. Moreover, the sequential line-ups included an absolute stopping rule (which is not always used in the field) and eyewitnesses were informed of the number of images to be shown (which is not as common in laboratory studies); meaning that comparison with earlier results are less clear-cut. However, the main finding is that there are visual limits to eyewitness accuracy that are moderated by eyewitness age and to a certain extent by line-up type.

### **5.1.2 Study II: The Interactive Effects of Distance and Lighting**

Approximately 50% of all crimes take place after 8 p.m. (Felson & Poulsen, 2003), which has been suggested to be partly due to the fact that darkness is a good cover for hiding activities and faces. Although we are all familiar with the fact that distance and lighting decrease visibility, surprisingly little research has focused on the impact of distance and lighting on eyewitness accuracy. To date, Study II represents the first published eyewitness results to have looked at the interactive effects of actual distances and actual lighting conditions on identification accuracy when using live targets. Earlier studies have suggested *the Rule of Fifteen*, which states that in order to keep a diagnosticity of 15, lighting conditions should be above 15 lux and the distance should be below 15 meters (Jong et al., 2005; Wagenaar & Van Der Schrier, 1996). The results from Study II do not provide evidence contrary to *the Rule of Fifteen*, however, our results do imply that there are also other thresholds to take into account. Our findings suggest that at 20 meters in lighting conditions of approximately 1 lux (i.e., moonlight), accuracy is at chance level. These findings are based solely on target present line-ups that did not include target absent line-ups or allow a line-up rejection, which limits their generalizability to eyewitness identifications in real life. However, the patterns of high versus low accuracy as distance increased and lighting decreased is exactly what we would expect based on the fundamentals of visual perception (Ferwerda, 1998; Hiraoka et al., 2015; Tidbury et al., 2016; Zele & Cao, 2015). Moreover, at 20 meters in 10 lux (i.e., twilight in public areas) accuracy was roughly 50%, which was an almost 30% decrease in accuracy from 6 meters; suggesting that with increased distance, accuracy would decrease even further. Establishing these interactive thresholds can help the police and the judicial system to better assess the accuracy of eyewitness identifications.

### **5.1.3 Study III: The Effects of Line-up Positions**

The main findings of Study III were that distance and age moderate image selection patterns so that as distance increased there was an overall increased tendency to select an image from the first line-up position (compared with line-up positions 2–8). Compared with young adults (18–44), young children (6–11) were overall the most likely to select the first image (vs. line-up position 2–8) in a sequential line-up. In simultaneous line-ups, we found a weak top row preference that was in line with

earlier findings (Carlson et al., 2019; Palmer et al., 2017) but the preference was also moderated to a certain extent by distance and eyewitness age.

In sequential line-ups, eyewitnesses who are aware of the number of pictures they will see are more prone to choose an image towards the end of the line-up (Carlson et al., 2016; Horry et al., 2012; Meisters et al., 2018). However, similar results have been found when eyewitnesses were not given that information (Carlson et al., 2016; Meisters et al., 2018). In Study III, despite all the eyewitnesses knew the number of images they would see in both line-up types, we nevertheless found a tendency towards selecting the first image in sequential line-ups. This preference was especially present in young children and the oldest adults, but all age groups showed a first position preference as the viewing distance increased. Comparisons with earlier studies are difficult because they have not usually systematically investigated position effects in a similar way to our study (i.e., complete randomization of line-up positions). Nevertheless, the overall increase in first position selections may reflect a metacognitive error by all participants in failing to gauge the task as more difficult as the viewing distance increased and opting to try to guess rather than reject the line-up (Mansour et al., 2012). Such a tendency to guess might be the result of not wanting to miss the opportunity to identify a target (Smith, Wells, Lindsay, & Myerson, 2018). Thus, the increase in first line-up position selections could be seen as the adoption of a more liberal response bias, which would explain the overall increased frequencies of first line-up position selections (Wilson et al., 2019).

To investigate response bias, we explored the confidence accuracy association in the first line-up position compared with the association in line-up positions 2–8 per age group (with distance collapsed). We found an association between high confidence (91–100%) and identification accuracy for older children, young adults, and older adults, but for young children and the oldest adults the association was less clear. Earlier findings also indicate that compared with young adults, the confidence accuracy relationship is less well calibrated in children (Brackmann, Sauerland, & Otgaar, 2019) and older eyewitnesses (Martschuk et al., 2019). However, the novelty of our results is that we also found that the response criterion was different for line-up position 1 vs. line-up positions 2–8. More specifically, we found that the confidence accuracy relationship of young children (6–11) and the oldest adults (60–77) was similar to young adults in line-up positions 2–8 but not in the first line-up position. In the first line-up position, young children and the oldest adults made more erroneous high confidence identifications, indicating that they were not well calibrated. In the subsequent line-up positions, they were more conservative and made less errors and more accurate high confident identifications. Although our interpretation of the CAC analysis results is not based on a significance test, these results lend tentative support for the notion that there is a first position bias in younger children and the oldest individuals. This may be due to a subgroup of young children selecting more because of inhibition deficits and a subgroup of the oldest adults selecting more due to reliance on familiarity. If not, it is difficult to explain why the confidence accuracy relationship in line-up position 2–8 was similar to

adults, whereas the first line-up position was not well calibrated. These findings are both novel and concerning. They provide indirect evidence that disinhibition in young children and a reliance on familiarity might explain why some younger and older participants fare worse than young adults and why these groups show an increased tendency to select from the first line-up position.

Overall, our results suggest that there is an increased risk of a misidentification in the first line-up position, especially when the eyewitness is a young child or an older adult. In some policy recommendations, this problem is already alleviated through the recommendation not to place the suspect in the first line-up position in sequential line-ups (e.g., Bill Blackwood Law Enforcement Management Institute of Texas, 2015). Nevertheless, an increased selection of the first position minimizes the possibility of selecting the suspect later in the line-up if a stopping rule is employed (i.e. the line-up presentation is not continued after the witness has made a selection). Moreover, if it became common practice and commonly known that suspects are never placed in the first position, then perhaps the problem would shift to the second line-up position. The implications of the findings are that sequential line-ups should be used with caution with young children (6–11) and adults above 60, and that after having observed a perpetrator at a greater distance (or having a weak memory trace for other reasons), a sequential line-up might not be appropriate. To better gauge the severity of the risk associated with age and sequential line-up accuracy, future studies should focus on explicitly investigating selection patterns in sequential line-ups in relation to inhibition in children and reliance on familiarity versus recollection in older adults.

#### **5.1.4 Study IV: Estimation Accuracy**

Our results in Study IV show that when using a systematic and standardized approach to collecting estimations from eyewitnesses, the objective distance between the witness and the perpetrator and the age of the eyewitness moderate estimation accuracy. This is in line with earlier findings (Lindsay et al., 2008), but here we investigated distances up to 110 meters which is more than double the maximum distance previously investigated. Although the negative effect of increased distance on estimation accuracy was not large, our findings suggest that an increase in distance does decrease accuracy and augments the risk of making serious errors. Moreover, young children and older adults were more prone to making less accurate estimates, which further increases the risks of faulty estimations. The finding that high accuracy decreases, and serious errors increase with increased distance is disconcerting because person descriptions and estimations are used to identify and exclude potential police suspects. As mentioned earlier, estimation accuracy is not equal to descriptive accuracy, however, they are closely linked and our findings may, to a certain extent, be generalized to the use of eyewitness descriptions in the field. During trials, person descriptions are often used to show agreement between the suspect's appearance and the description by the eyewitness (Meissner, Sporer, & Schooler, 2007). Serious errors are specifically problematic because they increase the likelihood of apprehending the

wrong suspect. If a perpetrator is, for example, 30 years of age and 190 centimeters tall and an eyewitness (due to the long viewing distance) describes them to the police as 20 years of age and 170 centimeters, this can lead to the detainment and later conviction of an innocent person. Combined with Study I, these results imply that objective distance and eyewitness age are factors that should be paid close attention to by both courts of law and researchers. Furthermore, considering the question of a threshold for estimation accuracy, it appears that at least for gender (where chance accuracy is .50) we could not identify a visual threshold. Regarding the estimations of age, height, and weight, defining a threshold also depends on the criteria used to define accuracy. However, using +/- 2 units as we have done, we see that the likelihoods are on average well below .50, and although chance performance cannot be calculated in the same way as with the binary outcome of gender, it does indicate that the likelihood of high precision is very low even at the smallest distance (i.e., 5 meters).

## 5.2 Confidence & Response Time

Studies I, II, and III provide support for the confidence-accuracy relationship. Because Study I and III (but not Study II) included both target present and target absent line-ups, we were able to conduct confidence accuracy calibration analyses (CAC) (Mickes, 2015) showing that high confidence was associated with identification accuracy. However, there was a low number of high confidence decisions past 40 meters, which meant that we were unable to conduct the same analysis past this point in Study I. We have interpreted this as indicating that the suggestion that estimator variables do not impact the confidence-accuracy relationship might not hold true (Semmler et al., 2018), a conclusion that is further supported by other recent findings (Grabman et al., 2019). It is also important to remember that over-emphasizing the postdictive value of confidence neglects the fact that eyewitnesses in real-life cases have been found to lie. For example, the 2016 report of the National Registry of Exonerations found that of the approximately 1900 post-conviction exonerations, 70% were due to tainted identifications; of these 40% were intentional lies and 30% were unintentional misidentifications (The National Registry of Exonerations, 2019). Furthermore, in Study III, when looking at the confidence accuracy relationship per age group and line-up positions 1 versus 2–8, we also found differences in the association between confidence and accuracy. We have interpreted our findings as indicating that there may have been subgroups among the young children and among the older adults that were less accurate due to inhibition deficits and reliance on familiarity. The results indicate that more research is needed regarding possible line-up position biases in sequential line-ups.

Studies I and II also afforded us the opportunity to investigate the association between response time and accuracy in line-ups. In both studies, we found a clear relationship between shorter response times (i.e., quicker decisions) and identification accuracy (in Study I for both simultaneous and sequential line-ups and in Study II for simultaneous line-ups). However, in Study I we found that the relationship was limited to approximately 40 meters, after which the association

weakened. These overall results are in line with earlier findings (Dunning & Perretta, 2002; Sauer et al., 2008; Weber et al., 2004). However, no earlier studies have looked at the combined and interactive effects of response time and distance on accuracy; our findings do indicate that the relationship between accuracy and response time seems to be moderated by distance. Notably, our results from Study I are based on over 6200 line-up decisions and Study II on over 1300 line-up decisions, making the findings very robust.

### 5.3 Limitations

The present thesis and associated studies are not without their limitations. Studies I, III, and IV are all based on the same data collection and the four targets used in this data collection were relatively homogeneous. More varied targets would have been desirable and could be used in future studies. The data collection was conducted at a science center as a visual task and not using a mock crime event. Therefore, we could not investigate some aspects that may be relevant to real-life forensic settings, such as the effect of being asked the same questions by a police officer in a more realistic mock crime event. However, we were interested in the visual limitations of eyewitness accuracy, therefore there was no need to include the additional mock crime design because it would have reduced the optimal conditions of the experimental design. Moreover, in all four studies we used prospective designs, meaning that participants received comprehensive information of the whole design and the line-up tasks before participating. The benefit of this design is that it makes the encoding conditions as optimal as possible, but in contrast did not allow us to investigate the effect of some variables, such as line-up decisions with no prior knowledge of the number of images to be shown. Study II was also limited by the forced choice design and the lack of target absent line-ups, so the generalizability of the results is limited. However, the study nonetheless provides a first step into the investigation of the interactive effects of distance and lighting on eyewitness accuracy in order to establish a threshold of reliability. We also used a repeated task design in all our studies, and this could cause concern for possible carry-over effects between trials that might negatively influence the outcomes and the generalizability of the results. However, we did not find any order effects and it has been found that repeated measures designs do not negatively impact eyewitness decisions (Mansour, Beaudry, & Lindsay, 2017).

In all four studies, a more thorough evaluation of line-up bias would have added to the robustness of the studies. Additionally, evaluating effective size (i.e., the number of viable fillers)(e.g., Malpass, Tredoux, & McQuiston-Surrett, 2007) would have given added value. If there are few plausible fillers and the line-up is biased towards the target, this would lead to an increased risk that the target will be selected. However, as we included multiple targets and line-ups (4 in Studies I and III, and 8 in Study II) and took targets into account in our multilevel analyses, we feel that coupled with the large sample sizes, our overall results are robust. The implications of biased line-ups, assuming that our statistical approach was not adequate to



combat possible bias, is that our visual thresholds may be too high and that with fairer line-ups, the upper distance threshold would have been reached sooner.

## 5.4 Practical Implications & Future Directions

The most significant results in the current thesis are that eyewitness age, objective distance and lighting, as well as line-up positions clearly impact eyewitness accuracy. Increased distance had a dramatic negative effect on accuracy so that by 40 meters accuracy was between 25 and 35%, and for young children and older adults, accuracy was lower than for young adults. However, between 5 and 10 meters diagnosticity was already low, indicating that participants were unable to effectively encode the target even under optimal viewing conditions. Furthermore, by 100 meters accuracy and line-up diagnosticity (i.e., the likelihood that the person chosen is the actual perpetrator) were so low that this can be considered the visual limit of any eyewitness; with lower thresholds for the youngest and oldest age groups. These results were also achieved in optimal conditions, with optimal viewing conditions and minimal memory strain. This implies that for real-life identifications, much lower thresholds can be expected in most situations. Moreover, the combined effect of distance and lighting suggests that the upper distance threshold is dramatically decreased by lower lighting. However, more research is needed in order to find visual eyewitness boundaries for the interactive effect of distance and lighting on accuracy.

It has been argued that live line-ups are superior to video or photo line-ups, however, there is no clear evidence for this claim. In fact, there is some evidence suggesting that photo and video line-ups, apart from obviously being more practical to conduct, actually reduce confounds (Fitzgerald, Price, & Valentine, 2018). Moreover, although a video line-up offers more visual dynamics compared with a photo line-up (due to the possibility of a person rotating their head), there is no convincing evidence that one is superior to the other (Fitzgerald et al., 2018). Nevertheless, although there is no reason to suspect that the effects of distance, lighting, age, and line-up type would differ using a video line-up (compared to a photo line-up), a video line-up could be considered a way of further optimizing the eyewitness task by including a dynamic line-up that is as close as possible to the original observation of a live person rotating their head.

Additionally, an important and novel finding is that in sequential line-ups, young children and the oldest adults showed a first position bias. That is, they were less accurate and less well calibrated in the first line-up position compared with line-up positions 2–8. This is a worrying finding and there is a clear need to further investigate the combined (and interactive) effects of facial encoding strength, eyewitness age, and line-up type. Nevertheless, considering the robustness of our data collection and the sample size, the results from Study III suggest that sequential line-ups should be used with caution with young children (6–11) and adults above 60. These findings, in combination with the overall age comparisons included in Studies I, III, and IV, are of great importance to the field of eyewitness research because they represent much

needed comparisons of participants of different ages. Research on eyewitnesses has predominantly been conducted on young adults with less focus on children and still less on older adults (Erickson et al., 2015; Fitzgerald & Price, 2015). Participants are also often quite homogenous (i.e., university students) (Henrich, Heine, & Norenzayan, 2010), whereas the sample of Studies I, III, and IV, is based on a varied population outside of a university context; thus adding to the generalizability of our results.

Two main causes for the continued problems with eyewitness identifications are that 1) judges and jurors are often not able to correctly assess the reliability of individual eyewitness identifications (Wise & Safer, 2004; Wise, Sartori, Magnussen, & Safer, 2014) and, 2) in the rare cases when an expert witness is consulted by the courts, the group-level results reported by the expert are difficult to apply to the individual case. The problem of applying empirical research based on group data in judicial contexts has been termed the Group-to-individual (G2i) problem (Faigman, Monahan, & Slobogin, 2014). According to Faigman, Monahan, and Slobogin (2014) the majority of scientists measure group level phenomena whereas trial courts consider cases individually. The G2i problem is ubiquitous within the judicial system. Cutler and Wells (2009) have taken the position that “[t]he state of the science. . . does not permit an assessment of the accuracy of an individual eyewitness”, and “. . .any statement that allows the jury to infer that the expert believes a specific witness to be inaccurate, whether in response to a direct or hypothetical question, is a scientifically unsupported use of expert testimony.” (Cutler & Wells, 2009). Research shows that using group-level aggregated results in order to assess individual performance can be worryingly inexact (Fisher, Medaglia, & Jeronimus, 2018). In witness psychology, the G2i problem implies that central tendencies found in empirical studies may not apply to a particular witness. In fact, courts (in the US) often disallow expert witnesses from commenting on the individual performance of an eyewitness (Faigman et al., 2014).

Evidently, there is a fundamental rift between the attempts of scientists to generalize and the requirement of courts to particularize. However, the result of the present thesis, more specifically the distance threshold of Study I, can be used in individual cases, as our results, which are based on a large sample size and age range show that it is extremely unlikely for an eyewitness to be accurate after having witnessed a person at 100 meters. We argue that courts and experts can use these extreme threshold values as inclusion or exclusion criteria also in individual cases. Although subjective estimates of viewing distance and lighting conditions are most likely not very reliable, it is possible to obtain more objective estimates. For example, police forensic evidence of the crime scene, time of day, weather conditions, and the artificial illumination in the area, could give a reasonably objective approximation of the viewing conditions. This could then be used by the courts.

Future research should focus on the interactive effect of distance and lighting on eyewitness accuracy in combination with other factors, such as, stress (Deffenbacher,

Bornstein, Penrod, & McGorty, 2004; Roozendaal & McGaugh, 2011; Sauerland et al., 2016), the weapon focus effect (Erickson et al., 2014; Fawcett et al., 2013), attention (Brigham, Maass, Snyder, & Spaulding, 1982; Jacoby, Woloshyn, & Kelley, 1989), and the other race effect (Chiroro, Tredoux, Radaelli, & Meissner, 2008; Wan et al., 2017). Additionally, future research should investigate the effect of distance and lighting on eyewitness accuracy in combination with inhibition deficits in young children and recollection deficits in older adults in relation to selection patterns in sequential line-ups. This is because it is highly likely that all of these factors have an interactive and negative impact on eyewitness accuracy, thus further reducing the thresholds of reliability and accuracy.

## 6 References

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Thomas J. Nyman

## Witnessing an Unfamiliar Person:

The Effects of Distance, Lighting, Age,  
Line-up Type, and Line-up Position on  
Eyewitness Accuracy

Mistaken eyewitness identifications are an important reason for wrongful convictions. This study investigated from how far and under what lighting conditions a witness could make observations that would allow for a later correct identification. Based on 7551 eyewitness decisions, we found that accuracy declined from approximately 50% at 5–10m to 30% at 40m, and to practically chance level at 100m. Additionally, young children and older adults were less accurate than young adults. In low lighting (i.e., 1 lux), accuracy was reduced to guesswork already at 20m. We also found that young children and older adults were prone to selecting the first image shown to them—when a line-up was presented one picture at a time—increasing their chances of a misidentification. Finally, participants made many mistakes when describing the person seen and errors were somewhat more likely when distances were longer (e.g., over 10 year estimation errors regarding age more than doubled from 5m to 100m).