

Facing the Illusion Piece by Piece

Face recognition for persons with learning disability

Henrik Danielsson



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Papers

This thesis is based on the following papers which will be referred to as Papers I, II, III, and IV throughout the text.

- I. Danielsson, H., Rönnerberg, J., & Andersson, J. (in press). What am I doing in Timbuktu: Person–environment picture recognition for persons with intellectual disability. *Journal of Intellectual Disability Research*.
- II. Danielsson, H., Rönnerberg, J., Levén, A., Andersson, J., Andersson, K., & Lyxell, B. (in press). The face you recognize may not be the one you saw: Memory conjunction errors in individuals with or without learning disability. *Scandinavian Journal of Psychology*.
- III. Danielsson, H., Rönnerberg, J., Levén, A., & Andersson, J. (2006). *Verbal overshadowing and memory conjunction errors in persons with learning disability*. Manuscript submitted for publication.
- IV. Danielsson, H., Rönnerberg, J., Levén, A., Andersson, J., & Lyxell, B. (2006). *Memory conjunction errors and working memory capacity in persons with learning disability*. Manuscript submitted for publication.

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Introduction

General Purpose

The general purpose of this thesis was to investigate face recognition for persons with or without learning disability.

Organization of the Thesis

This thesis is organized in the following way. After the general purpose, a theoretical background is presented. The learning disability section describes what learning disability is and what kind of problems persons with learning disability can experience in their everyday life. The use of symbols and pictures as cognitive assistance is also illustrated. Following this, an exposition of the relevant face recognition literature is made. The next two sections describe memory conjunction errors, two theoretical approaches to memory conjunction errors and the relation to working memory. The specific research questions are presented before the methodological issues section followed by the summary of the four papers included in this thesis. In the general discussion, the main points from the papers are further evaluated. First, a new approach to understanding of face recognition and memory conjunction errors is presented. Then, the implications of the results from the papers are discussed in relation to witness psychology and to the use of photographs as cognitive assistance. Finally, some of the features of disability research are discussed before the thesis is summarized and further research is suggested.

Learning Disability

Definitions

In Sweden, there are three main ways to define learning disability (Sonander, 1990). The psychological definition relies on having a lower IQ than 70, as measured by an intelligence test. The social definition means that persons have a learning disability if they have limitations in adaptive behavior, that is, they have problems in everyday life situations demanding social, practical and school-related abilities. This implies that whether a person qualifies as having a learning disability or not changes over time. The administrative definition is based on that both of the other two definitions must be fulfilled. In this thesis, the administrative definition has been employed as a definition of whom to include as having a learning disability.

The persons with learning disability who have participated in the studies included in this thesis have been recruited from special schools and day care centers for persons with learning disability. These persons were already diagnosed as having a learning disability by a psychologist to qualify for these special environments. Therefore, it has not been necessary to include tests of intelligence and adaptive behavior in the inclusion criteria.

In a review of definitions of learning disability (Simeonsson, Granlund, & Björck-Åkesson, 2002) different terms for learning disability were discussed. Intellectual handicap, mental handicap, mental deficiency, mental retardation, intellectual disability, developmental disability, and learning disability are terms that have been used to describe a similar population through different times and across countries. The authors favors the use of the term learning disability, since the other terms are problematic in different

ways. For example, the word developmental is misleading since it denotes a stable, nondeveloping condition.

The World Health Organization has developed a system for International Classification of Functioning, disability and health (ICF; World Health Organization, 2001). It stresses that disability is always related to participation in an activity. Therefore, Simeonsson, Granlund, and Björck-Åkesson (2002) argued that combinations like intellectual disability and developmental disability are problematic compared to learning disability, which puts the disability in relation to an activity like learning of a particular material or task instead of an ability like intelligence.

The term persons with learning disability is used throughout this thesis to denote the participants, independent of the term learning disability is used in the cited articles. The only exception is in Paper I. Since it is published in Journal of Intellectual Disability Research, the term intellectual disability was used there. The decision to use the term learning disability in this thesis was also natural since almost all participants did attend some type of school for persons with learning disability.

Cognitive Profiles and Ethical Concerns

A way to describe the cognitive abilities of persons with learning disability is Gunnar Kylén's three stages of learning disability (Kylén, 1981), which is inspired by Piaget's theory of cognitive development (Piaget, 1968). The stages are different with respect to concepts of reality and concepts of abstract thoughts.

The A stage (severe learning disability) is characterized by acting and understanding in the present time and space. The concepts of space and time are limited, and the concept of time does mostly consist of more or less well

grounded guesses. A person at this stage is mainly thinking by acting. He or she is not able to speak but can use signals like body language and sounds (Kylén, 1981).

The B stage (moderate learning disability) is characterized by understanding the present as a whole and understanding what you have personal experiences of. Persons at this stage do not reflect on things they do not have experience of. They can differentiate between little and much, and can use some numbers. The time perspective has been broadened to include one or two days. Distinct pictures can be used for communication (Granlund & Olsson, 1988).

Persons at the C stage (mild learning disability) understand that there are places that they have no experiences of and that there is a future and a history. They also understand that there can be different ways to the same place. The concepts of day, week, and year is clearer. Conceptions of persons that you have not met and places that you have not visited exist. This gives a better chance to manage new environments and changes in the present environment. Persons at this stage can also manage to read, write and count to some extent (Granlund & Olsson, 1988). Abstract concepts are however not well understood.

In the papers included in the present thesis, mainly persons at the B- and C stages participated. This is due to the fact that they can understand instructions better, and hence, are easier to include in a test situation. In addition, there are ethical concerns regarding the inclusion of persons that we already predict will have great problems in the test situation. We do not want to expose them to a situation where they are predicted to fail almost all the time. Besides that, even if we receive written consent from the participants, as we always require, one cannot take it for granted that

participants with severe learning disability can understand what they agree to. In essence, it means that maybe they do not want to participate, even if they have given a written consent.

Use of Photographs as Cognitive Assistance

Svensk (2001) described the problems persons with learning disability can experience in their everyday life. He analyzed their problems in everyday life and came up with solutions of cognitive assistance, that is, anything that can assist cognitive processes, including artifacts and other persons. Svensk also stressed the importance of cognitive solutions that give a feeling of security, context, experience, and precision. Security means that persons and technology can be trusted in the sense that they are predictable, have continuity, and provide a structure. The concept of context refers to that it is important to get an overview of a situation and how different parts relate to the whole, to understand why to do things. Experience is important since persons with learning disability can have problems to imagine and relate to things and persons that are not present. Therefore, the need for cues that relate to personal experiences should be used. It is also important not to require judgments on sliding scales, but instead offer precision by giving each concept clear cognitive contours.

With the growing use of digital cameras, photographs are more often used instead of or as a compliment to the traditional picture systems in Scandinavia (Danielsson, 1997; Hansen & Bruus-Jensen, 2000; Jönsson & Svensk, 1995). The starting point was probably the Isaac project (Jönsson, Philipson, & Svensk, 1998; Jönsson & Svensk, 1995) in 1993 at Certec, Lund University in Sweden. The project developed a personal digital assistant with features like a mobile phone, GPS, digital camera, and

software for planning and communication support. The opportunity to take many photographs with the digital camera was the feature that the users prioritized. Other projects have involved photographs taken with digital camera for different kinds of disabilities, like aphasia (Andersson, 1997, 1998, 1999; Danielsson, 1997), learning disability (Andersson, 2000; Sporre, 2000; Stenkilsson & Alfonsson, 2000), and autism (Andersson, 2000; Mandre, 1999). One particular project initiated a discussion forum on the internet for people who are interested in using photographs taken with digital cameras.

In the year 2000, we started to analyze what people on the discussion forum stated they had used photographs for persons with learning disability or other types of cognitive disabilities for (Danielsson & Svensk, 2001). This resulted in nine categories, which are presented in Figure 1.

Each category is given a representative example: Photographs taken during an excursion can be used as *documentation*. *Self-awareness* can be created by using photographs of a person when he expresses a feeling so that he can see how he looks like when he is happy or angry. Presenting different activities with photographs makes it easier to choose between them in a *situation of choice*. Representing the activities of the day with photographs in a schedule gives better understanding of *planning* and what is planned. Many photographs can be used in a *sequence* to tell a story. *Whishes and dreams* can be expressed and talked about by creating photographs of you meeting someone or visiting a place where you have not been. Photographs of things you have experience of give *stimulation of speech*. Moving the photograph of a carer to the vacation board, since the photograph user did not want to have that person in his schedule, is an example of how photographs can make it easier to take *initiatives*. Having several

photographs of important events present at the same time makes it easier to understand and relate to your *history*.

We continued that study and carried out an email survey to all registered users of the discussion forum where we asked if they were using photographs in the sense indicated by the categories above. The results, see Figure 1, show that photographs mostly are used in the same way as symbols traditionally have been used. However, other ways are also commonly used.

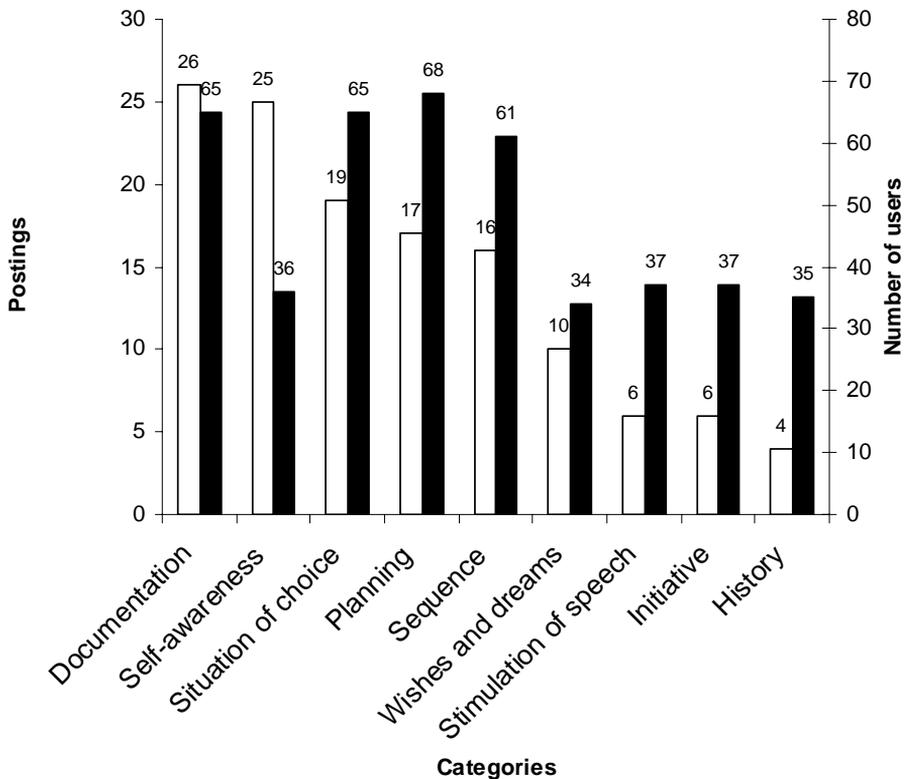


Figure 1. The numbers of postings in the discussion forum on the white bars and the number of user that used photographs for persons with cognitive disabilities on the black bars, divided on the nine categories of usage.

The study was the first to give an overview of how photographs taken with digital cameras were used for persons with cognitive disabilities. Therefore, it is important as a background for a more theoretical approach of the phenomenon studied in this thesis. One important thing to notice is that almost all of the categories imply using photographs of persons, either the person himself or herself, or someone else. This is one important precursor to why we have used photographs of persons in this thesis.

Face Recognition

There is evidence that face recognition is exceptional compared to other kinds of picture recognition (e.g., Elgar & Campbell, 2001). Bruce and Young (1986) proposed a model of face recognition that has become very influential. The model includes, for example, components for names, information about persons you know, structural information of known faces. As can be noted, it takes into account if a face is familiar or not to you. Recognition of unfamiliar faces (for a review see Hancock, Bruce, & Burton, 2000) is different from recognition of familiar faces.

In the research on face recognition of familiar faces different approaches have been used. Some studies used celebrities as familiar persons (e.g., Proctor & Pick, 1999; Davies & Milne, 1982), but it can be problematic since celebrities are not equally familiar to all persons. The way to deal with that has been to use the most famous celebrities. Since a lot of this research is British, or at least European, pictures of Prince Charles and Lady Diana have been used to a disproportionately large extent.

Another approach is to expose the participants to pictures a certain number of times (e.g., Dalton, 1993; Dubois et al., 1998; Thomson, Robertson, & Vogt, 1982). The number of exposures then represents the degree of familiarity. Studies that use what we normally refer to as a familiar person, that is, someone with whom you have a personal relation, are uncommon. Baddeley and Woodhead (1982) argue, from a methodological point of view, that the method to expose pictures a certain number of times is to prefer. This is because the degree of familiarity is initially equal for all face pictures and for all participants.

In the investigation of the use of photographs for persons with learning disability (Danielsson & Svensk, 2001) referred to above, almost all of the categories imply using pictures of persons. This was the argument for investigating face recognition. However, all photographs also have an environment. The relationship between the person and the environment in the picture has not been investigated for persons with learning disability. Therefore, this was investigated in Paper I.

An analysis of the lures used in Paper I showed that persons were more important for recognition than environment. Hence, the use of person-related lures was investigated in the further studies.

Memory Conjunction Errors

You have committed a memory conjunction error (e.g. Brown & Lloyd-Jones, 2001; 2002; Busey & Tunnicliff, 1999; Reinitz, Morrissey, & Demb, 1994; Reinitz & Demb, 1994), or a binding error as it also is called, if you falsely recognized an item that consists of previously studied parts as a previously studied whole. If you, for example, were to remember a word list that contains the words “Borderline” and “Deadhead”, you would have a strong tendency to claim that you had studied the word “Deadline” before. Figure 2 shows an example with photographs with the same combination logic.



Figure 2. An example of how morphed photographs were created. The inner parts of the photograph to the left together with the outer parts of the photograph to the right form the photograph in the middle, which is a conjunction face.

In a memory conjunction experiment there are often four types of pictures used: pictures that have been studied before, called Old pictures; Conjunction pictures, which was described above; Feature pictures, which are pictures created from one face half that has been studied before and from one face half that has not been studied before; and finally, completely New pictures to estimate a base-line of the guessing level.

To the best of our knowledge, no studies on memory conjunction errors for persons with learning disability have been made, except for the studies included in this thesis. However, studies on other special populations have been made. Persons with amnesia (Reinitz, Verfaellie, & Milberg, 1996), persons with hippocampal damage (Kroll, Knight, Metcalfe, Wolf, & Tulving, 1996; Stark & Squire, 2003), and older adults (Rubin, Van Petten, Glisky, & Newberg, 1999) have all been shown to have more problems with memory conjunction errors than controls.

Binding Approach

The binding approach (e.g., Kroll, Knight, Metcalfe, Wolf, & Tulving, 1996; Reinitz, Lammers, & Cochran, 1992, Reinitz, Verfaellie, & Milberg, 1996) assumes two types of representations: components and configurations. Components, which are lower-level representations like for example facial features, may be bound together to form more configurative representations like for example a face. Conjunction errors are thought to be based on blending components erroneously through either retrieval failure of the configuration (Reinitz et al., 1992, 1996), or from inaccurate encoding of the configuration (Kroll et al., 1996).

Two mechanisms were suggested by Kroll et al. (1996), namely a binding mechanism and a binding mechanism inhibitor. The binding

mechanism permits the individual to bind encoded components of the stimuli together, independent of whether they were presented simultaneously at encoding or not. The binding mechanism inhibitor uses the configurations and protects from inappropriate binding of elements that do not belong together. Conjunction errors occur when the binding mechanism inhibitor does not prevent the binding mechanism from inappropriate binding.

Dual Processing Approach

In a dual-processing approach (e.g., Bartlett, Searcy, & Abdi, 2003; Jones & Jacoby, 2001; Jones, Jacoby, & Gellis, 2001) to memory conjunction errors (for a review of dual processing in general, see Yonelinas, 2002) recollection (e.g. Brainerd & Reyna, 2002; Brainerd, Wright & Reyna, 2001; Lampinen, Odegard, & Neuschatz, 2004) and familiarity (Odegard & Lampinen, 2004) are supposed to be independent processes that contribute to recognition memory performance. Familiarity is a relatively fast and automatic process that gives a feeling of having seen something before without the possibility to consciously recollect the episodic elements surrounding the events. Recollection is a relatively slow, controlled strategic process that includes the conscious re-experiencing of the encoded picture. Familiarity with components may erroneously cause recognition of feature pictures and conjunction pictures. Recollection of the encoded stimuli can help to avoid such false recognitions.

Comparison Between the Approaches

As can be noted, there are similarities between the two approaches. However, one for this thesis important difference is that the binding mechanism consists of two components that use automatic processing, whereas the dual processing approach uses a controlled recollection

component in addition to the use of the automatic familiarity component. Persons with learning disability are as good as age-matched controls in automatic processes (e.g., Bray, Fletcher, & Turner, 1997), whereas their performance is lower in controlled and strategic processing tasks (e.g., Wyatt & Conners, 1998).

Examples of automatic processing tasks where no group difference have been found are: frequency of occurrence for words (Ellis, Palmer, & Reeves, 1988), the ability to remember spatial locations of pictures in a book (Dulaney & Ellis, 1991; Ellis, Katz, & Williams, 1997; Ellis, Woodley-Zanthos, & Dulaney, 1989; Nigro & Roak, 1987), and speech rhythm influence on sentence comprehension (Dann as cited in Bray, Fletcher, & Turner, 1997).

There are also other differences between persons with learning disability and controls (for a review, see Bray, Fletcher, & Turner, 1997). For example, there are differences in attention (Tompsonowski & Tinsley, 1997) speed of information processing (Nettelbeck & Wilson, 1997), and working memory (e.g., Henry, 2001; Numminen, Service, Ruoppila, 2002). However, these differences affect all conditions of recognition to the same degree. By using adjusted scores, where the performance for new pictures, which can be considered as a base-line condition, is subtracted from the performance of the other conditions, the group differences that are equally distributed over all conditions are canceled out.

Working Memory and Binding

There are many different views on what the notion of working memory is and how it works (for a historic review of different views of working memory see Logie, 1997). However, most researchers would probably agree that working memory is a system for on-line storage and processing of information, and that the resources available for this mechanism are limited (Richardson, 1997). Miller (1956) estimated the short-term (working memory) capacity to be “the magical number seven, plus minus two”. Later, Cowan (1997) modified this to “the magical number four”. Recently, Olsson and Poom (2005) modified this to a capacity of only one item. The reason for this drop in the estimate of working memory capacity over time is related to different theoretical viewpoints. Seven represents the working memory capacity in everyday situations where strategies like chunking can be used. Cowan (1997) prevented the participants from chunking information and demonstrated a capacity of only four items. Olsen and Poom (2005) suggest that only one item at the time is in the focus of attention, but there is another subset of three items which is more activated than relative to the whole set of items studied. All these studies have in common that they belong to the same research tradition, namely the one that assumes a unitary or general working memory capacity.

An alternative to the general capacity assumption is a multicomponent model. Baddeley and Hitch (1974) proposed a model of working memory, which in its updated version (Baddeley, 2000) includes four components: the phonological loop, the visuospatial sketchpad, the central executive, and the episodic buffer. The phonological loop and the visuospatial sketchpad are storage components that provide temporal storage for verbal and visuospatial

information, respectively. The central executive is the coordinating mechanism for the other components. The episodic buffer was included in the model recently (Baddeley, 2000), as the model was revised to focus more on integration of information. The episodic buffer provides temporary storage of information and is binding information from long-term memory and the other three components of working memory into a unitary, episodic representation (Baddeley, 2000).

Three of the papers included in this thesis investigated the ability to bind features in memory. These papers, and especially Paper IV, set out to discuss the relation between binding and working memory. One argument for investigating this relation was that binding is included in the description of the episodic buffer component of working memory. Therefore, it can be argued that a binding test is a test of one aspect of the episodic buffer. There are, however, very few tests of the episodic buffer since the component is relatively new, and the theory of the episodic buffer is relatively undeveloped.

Rethinking the span test by Daneman and Carpenter (1980) it can be argued that since a semantic judgment is made for each item, long-term memory knowledge is used. Since the episodic buffer binds information from the long-term memory and the other working memory components, it can be said that such a complex span test uses the episodic buffer. Therefore, span tests (Daneman & Carpenter, 1980), which rather belong to the general capacity tradition, were used in the papers included in this thesis.

It should also be noted that persons with learning disability empirically demonstrates lower working memory capacities than age-matched controls (e.g., Henry, 2001; Numminen, Service, Ruoppila, 2002). This offers the

possibility to investigate the relation between memory conjunction errors and working memory in a broader working memory range.

There have been studies that have investigated the involvement of working memory in memory conjunction errors. Reinitz and Hannigan (2001) found, when the encoding faces were presented in pairs, higher error rates for conjunctions created from faces within the same pair than for conjunctions created from faces from different pairs. Reinitz and Hannigan (2004) interpreted this as caused by the fact that items presented as pairs are simultaneously present in working memory and may therefore be indiscriminately inter-associated with each other.

Reinitz and Hannigan (2004) replicated the result and developed it further. Their results showed that when rehearsal of the studied items was prevented, the difference between performance for conjunctions from within-pairs and between-pairs did vanish. Rehearsal is typically assumed to be carried out in working memory. Therefore, this is an indication that memory conjunction errors are related to working memory, but working memory as such was not assessed in the study.

Specific Research Questions

The section on face recognition, where familiarity for faces and the relationship between the person and the environment in the picture was discussed, constitutes the background for the first question: how does familiarity of faces interact with familiarity of environment in pictures for persons with learning disability? This is investigated in Paper I.

The interest to investigate person-related lures lead to the memory conjunction error section. It describes two theoretical approaches which are important for the second question: which, if any, of the two theoretical approaches to memory conjunction errors, the binding approach and the dual-processing approach, can explain performance for both persons with and without learning disability? This is investigated in Paper II and III.

Working memory and binding were presented in the last section. This set the stage for the third question: how does working memory relate to performance in memory conjunction error studies? This is investigated and discussed in Papers III and IV.

Methodological Issues

Managing Threats to Validity

To do research on persons with learning disability is quite different from doing traditional psychological studies. First, there are practical problems like to recruit participants. The easiest way to get in contact with many potential participants is to go via schools or day care centers. Here, the personnel must be convinced that it is a good idea to give you access to the persons with learning disability. The persons themselves must also be convinced that it is fun and in their interest to participate.

Second, the tests and test procedures typically must be adjusted to persons with learning disability. The test must be intuitive so that it can be understood by persons with learning disability. This, in combination with creating tests that do not display performance levels at floor or ceiling levels for any of the groups, is a true challenge. Besides this, a control group must also be composed in such a way as to control for relevant aspects, selecting just a few controllable aspects. However, inconvenience should not be an argument for not conducting disability research.

This type of research can also result in better methods for research in other areas. In Paper I, picture recognition for familiar and unfamiliar persons and environments was investigated. If we had just started with a classical recognition experiment, the results would have become problematic to interpret. Therefore, efforts to try to deal with possible threats to internal validity (Shadish, Cook, & Campbell, 2002) were made. Among the aspects that could affect the results were (a) if the participants had understood the instruction, (b) if they could recognize themselves on a picture (because this was one type of familiar person in the study), and (c) if they could match

two identical pictures with each other. First, a task which required the participants to identify a picture of the participant himself or herself was included. Secondly, a matching task was included to make sure that the participants could reliably match two identical pictures. Third, the instructions for the matching task were almost identical to those to be used in the recognition task. This had two purposes: to practice the instructions and to establish that the instructions had been understood before the recognition task.

Tests

This thesis focuses on the visual abilities of persons with learning disability. Therefore, the individual possibility to compensate with verbal abilities is a potentially confounding factor that should be minimized. This is important as the participants varied substantially on this factor. As a matter of fact, all tests in this thesis have been chosen to measure visual abilities with minimal influence of verbal abilities (with the exception of Paper IV, where verbal overshadowing was a manipulation). Thus, a nonverbal test of intelligence (Raven's coloured matrices; Raven, Court, & Raven, 1995) has been used in all studies. The purpose of that has been to gain control of the intelligence of the participants. A secondary purpose has been to have the possibility to divide the learning disability group into high and low intelligence groups to investigate if there are qualitative differences within the learning disability group.

Familiarity

In Paper I, pictures of persons with a personal relation to the participant were used. It is argued that familiarity in the sense of having pictures of friends is ecologically more relevant than pictures familiarized by many exposures. One methodological drawback with familiarity operationalized as personal relationships is that a large number of new pictures must be created for every participant in an experiment. This may in its turn create other unwanted confounding differences among the participant-specific pictures-to-be-recognized. Besides that, it is also difficult to find a place with persons with learning disability and age-matched control persons that share the same familiar persons and environments. All this taken into account, unique sets of pictures were used in Paper I without a control group. For the further studies, the possibility to have a control group was prioritized.

Summary of the Papers

Paper I

Purpose

The purpose of Paper I was to examine the effect of familiarity in recognition of persons and environments depicted in photographs for pupils with different degrees of learning disability, that is, children attending special schools for persons with learning disability in Sweden.

Method

Forty-five pupils from a school for persons with learning disability participated in a short-term picture recognition task (STPRT) and a long-term picture recognition task (LTPRT). In the STPRT, for the encoding pictures, three person on picture conditions, self, familiar person, and unfamiliar person, were orthogonally combined with two environment on picture conditions, a familiar and an unfamiliar environment. The STPRT was a three-alternative forced choice task. The test pictures were the same picture as originally at encoding plus an additional two out of four alternatives: (1) a correct person in false unfamiliar environment, (2) a false unfamiliar person in correct environment, (3) a false unfamiliar person in false unfamiliar environment, and (4) a mirrored correct picture.

To ensure that the participants had the abilities to recognize themselves and that they could manage to match two identical pictures, these basic prerequisites were tested in two screening tasks. In the LTPRT, the recognition was tested for the pictures of unfamiliar persons in unfamiliar environments from the STPRT after a week.

Results and Discussion

The results in the STPRT were analyzed with ANOVA with d' (a relation between hits and false alarms that compensate for guessing) as dependent measure. It was found that there were main effects of person on picture and environment on picture, where familiar pictures were more often recognized than unfamiliar ones. There was also a significant person by environment interaction, see Figure 3.

It was predicted that either a familiarity hypothesis or a figure–ground hypothesis would explain the interaction pattern. The familiarity hypothesis was that the more familiar the easier the picture should be to recognize. The figure–ground hypothesis predicted that the combination of familiar and unfamiliar person and environment should be the easiest to recognize. None of the hypotheses could explain the interaction pattern.

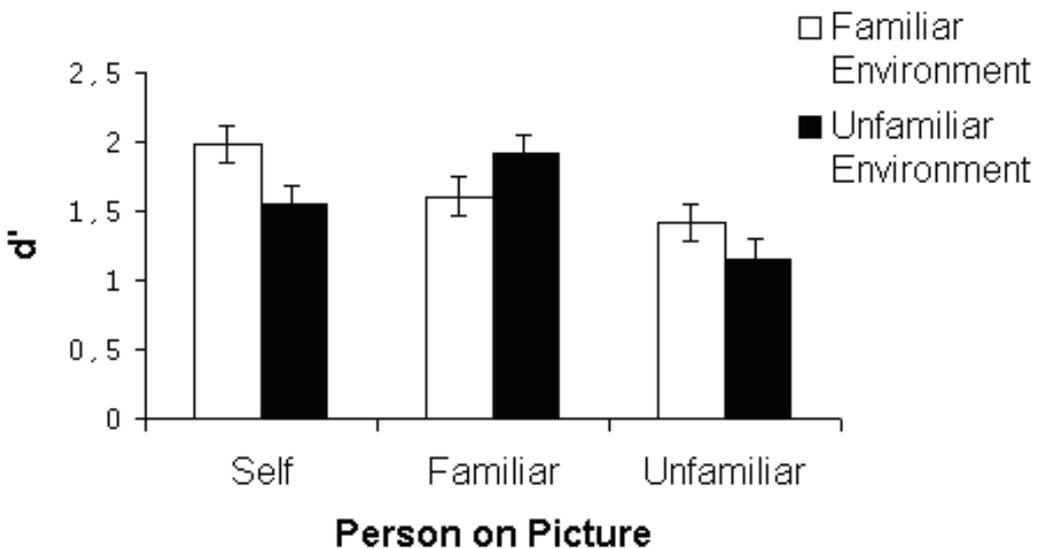


Figure 3. Person by environment interaction in the ANOVA on d' with standard errors marked on the bars.

The interaction is instead explained by the type of association between the person and environment on the picture (i.e., an absent, present or implausible association). When the person or environment (or both) are unfamiliar, the association is absent, since there is no personal experience of that combination, and retrieval must rely on episodic processes. If both the person and the environment are familiar, the association is present and semantic strategies can also be used, causing better performance. Pictures of yourself in an unfamiliar environment represent an implausible association, which may cause confusion since no episodic memory can be retrieved of the event even though the picture indicates that there should be one. This in its turn causes relatively lower performance compared to the condition with a present association. Hence, when possible, a lazy semantic strategy was supposed to be used which means that instead of actually remembering the depicted episode, a semantic description like “me at school” is remembered. This is cost efficient and works well in most cases.

The results of the LTPRT showed that the participants did recognize the pictures at the same rate independent of if they had recognized them in the STPRT or not.

Paper II

Purpose

The purpose of Paper II was to compare two competing theoretical explanations of memory conjunction errors, the *dual-processing approach* and the *binding approach*, in a group of individuals with learning disability and in a group of chronologically age-matched controls. Persons with learning disability were included since they, compared to controls, have

intact automatic processing but impaired explicit processing. This is further associated with different predictions for the two approaches.

Method

Twenty-three participants with learning disability and 18 age-matched controls participated in the study. The main task was a face recognition task with five encoding pictures presented sequentially. All eight test pictures that belonged to one of four different recognition picture types were presented sequentially and self-paced. The recognition types were (1) old pictures, (2) conjunction pictures that were created by combining face parts from two previously studied pictures, (3) feature pictures that were created by combining face parts from one previously studied picture and one new picture, and (4) new, nonstudied pictures. Ten different face sets with drawings and photographs were used, and all participants completed all sets. The drawings were the same as in Experiment 2 in Kroll et al. (1996) and in Experiment 6 in Reinitz, Lammers, and Cochran (1992). Pretests were used for training and for assessing that the participants could understand and manage the recognition task in a matching task version. The design of the main task was a $2 \times 2 \times 3$ split-plot factorial design with the variables group, material, and recognition type. The latter two were within participant variables.

Results and Discussion

First, it was found that the results for the controls followed the patterns of Experiment 2 in Kroll et al. (1996) and Experiment 6 in Reinitz, Lammers, and Cochran (1992), which verified that the same phenomenon was investigated in this study. Then, the results were analyzed by ANOVA. Adjusted scoring was used, meaning that the performance for new pictures

was subtracted from the performance for the other recognition types. Doing so, all main effects and two-way interactions were significant. The group by recognition type interaction is the most interesting one for comparison of the two theoretical approaches, and this interaction is shown in Figure 4.

Group differences were found for all recognition types, where the learning disability group demonstrated fewer hits and more errors. Generally, the results were in line with the dual-processing approach, given that a probable floor effect was taken into account. The binding approach received less support since it did not predict any group differences for any of the recognition types.

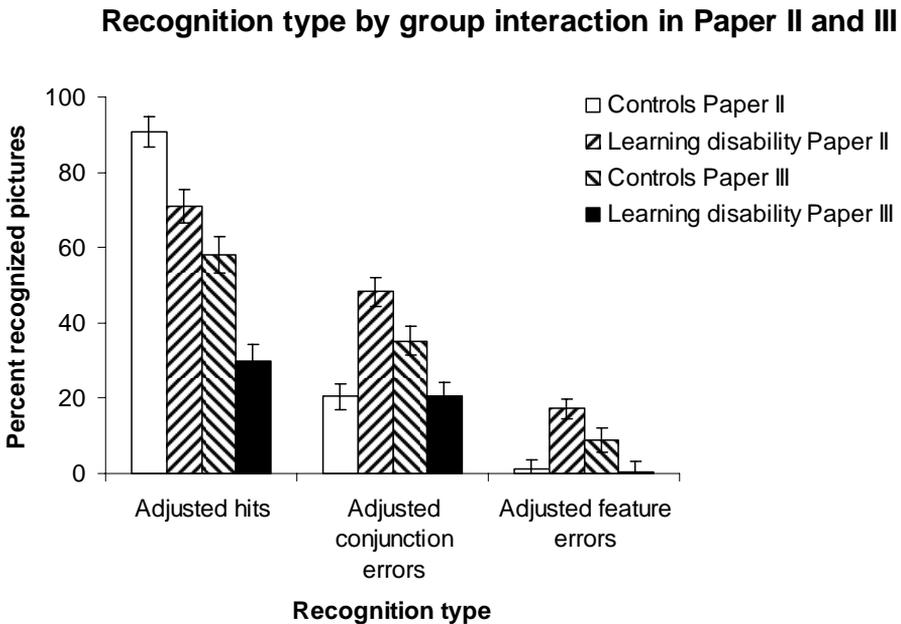


Figure 4. The recognition type by group interaction with standard errors marked on the bars for both Paper II and III.

Paper III

Purpose

The purpose of Paper III was to investigate memory conjunction errors and verbal overshadowing for persons with and without learning disability, and to investigate how these factors interact with each other. Verbal overshadowing is the effect of getting a lower recognition rate after describing the stimuli to-be-remembered compared to not having to describe them.

Method

Two groups participated in this study, 18 persons with learning disability and 20 age-matched controls. The main task was a memory conjunction task, similar to the one used in Paper II. The main differences compared to Paper II, were that, in this study, more encoding pictures were used (23 compared to 5), three different filler task conditions were used instead of none, and that only photographs were used. The first condition had an unrelated filler task and served as a control condition. The second filler task was to describe the last encoding picture detailed in three minutes. This was made to induce a verbal overshadowing effect. Since persons with learning disability can have problems to generate long descriptions, a third condition was also used. Here, the test leader read a description of the last encoded picture and the participants were to judge if the description was appropriate.

Results and Discussion

The results were analyzed with ANOVAs and the same adjusted scoring as in Paper II was used. No verbal overshadowing effect was found, which de facto several other studies also have demonstrated. The significant recognition type by group interaction is shown in Figure 4.

In this study the binding approach received more support compared to Paper II. For example, there was no group difference for adjusted feature errors. The dual processing approach, on the other hand, received less support. For example, the learning disability group made less adjusted conjunction errors than the controls, whereas the dual processing approach predicted a group difference in the opposite direction. However, none of the approaches can explain all results.

Therefore, a new frame of interpretation of the results was suggested. It was proposed that the group difference in the results was due to the fact that the learning disability group to a higher degree relied on feature-based than configuration-based face recognition, in combination with different working memory capacities. The lower working memory capacity of the learning disability group led to two effects: (1) The learning disability group recognizes fewer facial features than the controls, which leads to lower recognition for all adjusted recognition types. (2) The learning disability group is using configurations to a lower degree than the controls, which leads to less prevention of false recognition of conjunction and feature pictures. Task demands of working memory in relation to the individuals' working memory capacity determine the relative strength among the two effects on working memory.

Paper IV

Purpose

The purpose of Paper IV was to investigate the relationship between memory conjunction errors and working memory capacity. This was done for persons with learning disability and controls for two tasks with different working memory demands.

Method

Study 1. The memory conjunction error task was the same as in Paper II. The working memory task was a listening span task. Since not all persons in Paper II carried out the working memory task too, fewer persons were included in this study: 16 persons with learning disability and 17 age-matched controls.

Study 2. The memory conjunction error task was the same as in Paper III. The working memory task was a picture span task. Since not all persons in Paper III carried out the working memory task too, fewer persons were included in this study: 16 persons with learning disability and 21 age-matched controls.

Results and Discussion

The results were analyzed with correlations and supported the two effects of working memory proposed in Paper III. High demands on working memory made the participants rely on the effect of recognizing facial features to a higher extent, at the expense of the facial configurations. This was found for both groups. In fact, the correlation pattern for the learning disability group in the tasks with low working memory demands was similar to the one for the controls in the task with higher working memory demands.

Facing the Illusion

This implies that learning disability can be simulated by raising the working memory demands, at least in this type of recognition task.

General Discussion

The main findings in the four papers can be summarized as follows:

(a) The person by environment interaction found in Paper I was explained by an absent, present or implausible association between the person and the environment in the picture. These semantic relations determine performance and a “lazy” semantic strategy was suggested.

(b) Paper II and III showed that the group by recognition type interaction patterns were different for different degrees of task difficulty. These patterns could neither be explained by the dual processing approach nor the binding approach. Hence, a new frame of interpretation was suggested.

(c) Paper IV showed that high working memory capacity is associated with two effects: (1) recognition of more facial features and (2) recognition of more facial configurations. A consequence of higher working memory demands of the task was that participants relied on the first effect to a higher degree, at the expense of the other.

These main points are penetrated further and discussed in relation to theoretical approaches below. After that, applications to witness psychology and the use of photographs as cognitive assistance are suggested. Then a discussion on disability research follows before everything is summarized and further research is proposed.

A New Approach to Memory Conjunction Errors

Paper II and III clearly showed that both the binding approach and the dual processing approach have problems to explain the results. This can be used to adjust and improve the approaches to “save” them, which is discussed in Paper II, III, and IV. However, instead of that, this section

presents a new approach to understand memory conjunction errors, the working memory conjunction error approach (WMCE).

The findings in the papers included in this thesis suggest that there is a relation between working memory and memory conjunction errors. Working memory affects the recognition types in two different ways. High working memory capacity is associated with: (1) recognition of more facial features; (2) recognition of more facial configurations. The first effect is associated with higher recognition rates for old, conjunction, and feature pictures, since they all are constructed from previously seen facial features. It also prevents false recognition of feature and new pictures since the unseen facial features do that the picture can be judged as new. The second effect is associated with prevention of false recognition of conjunction, feature, and new pictures since those facial configurations have not been seen before. However, it also aids recognition of old pictures since that configuration has been seen before. The working memory effects distribution over the recognition picture types is shown in Figure 5.

The differences at encoding in the studies in Paper IV give different degrees of working memory involvement in the included studies. There are more faces to encode and a longer delay before the test in the second study. This is probably associated with lower quality of encoding of the faces. It should, therefore, be easy to conclude that the working memory effects are present at the encoding phase of the faces. However, there is only one face at a time to encode, which implies that the working memory demands are low. At retrieval, on the other hand, the retrieval face should be compared to the encoded faces. This is working memory demanding, especially when the faces are encoded with low quality. Thus, it is suggested that the above proposed working memory effects are present at retrieval.

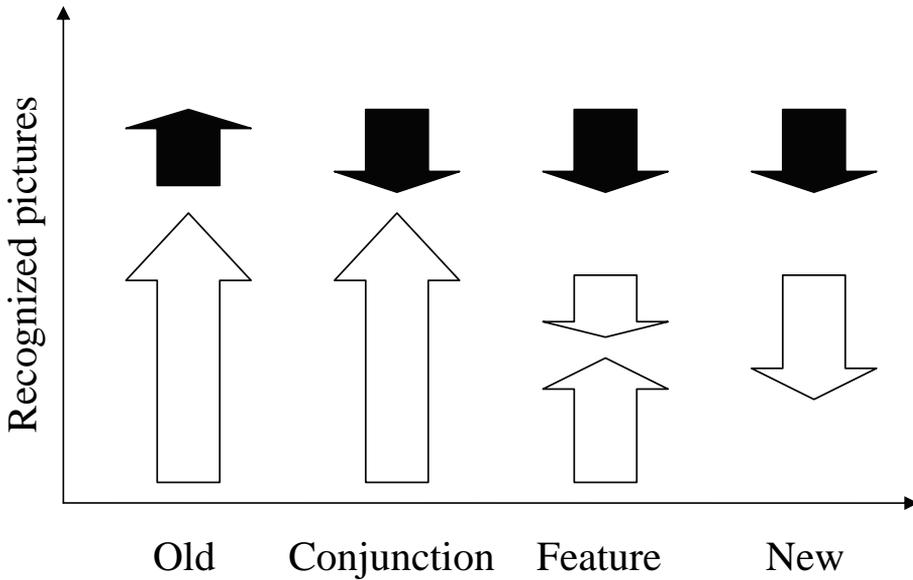


Figure 5. The proposed working memory effects distribution over the four recognition picture types is shown. The first effect that is associated with recognition of facial features is shown with white arrows, and the second effect that is associated with recognition of facial configurations is shown with black arrows.

The results in Paper II, III, and IV show that it is harder to recognize facial configurations than features, since configurations are more complex than features. The results also demonstrate that the relation between working memory capacity and how much the task taxes working memory determines the internal relative strengths among the two different effects of working memory capacity. When working memory resources are demanded to a higher degree, persons tend to rely to a higher degree on feature-based

recognition at the expense of the configuration-based working memory effects.

The results for memory conjunction errors from Paper II and III are shown in Figure 4. As can be seen, the reasoning above receives support for both groups. Moreover, high demands on working memory in relation to a person's own working memory capacity reveals interesting results. With high working memory demands like in Paper II and the first study in Paper IV, the controls perform at a similar level for all recognition types compared to the performance of the learning disability group in Paper III and the second study of Paper IV with low demands on working memory. It is of course not a perfect match of levels since the studies were not designed with the intention to try to match the levels. A further argument for the similarity is that there are also similar correlation patterns between the performance for the recognition types and working memory in the studies. This implies that learning disability is mainly characterized by a lower working memory capacity in this type of recognition task.

The new idea that a general working memory capacity limitation can be related to and "explain" another ability is not new. For example, Daneman and Carpenter (1980, 1986) found high correlations between working memory capacity and different kinds of verbal abilities. Even though the attempts to replicate the findings have been mixed (see Soltzfas, Hasher, & Zacks, 1997, for an overview) the idea that a general working memory capacity can account for other abilities was established. That idea does, however, differ in some respects from the proposed WMCE approach above. The WMCE approach takes into account how much the task taxes working memory relative to the individual's working memory capacity. It also includes two different kinds of effects of working memory, not just a single

one. The internal associations of the effect change by means of how much working memory capacity the particular task consumes for a particular individual.

Paper I suggested that familiarity with what is depicted is associated with higher recognition rates. The higher rates were, however, assumed to be a result of a more “lazy” semantic strategy. Remembering that it was a picture of me at school does indeed lead to higher recognition rates, but at the expense of falsely recognizing other than the target pictures of me at school.

Comparing this finding with the working memory findings above offers interesting similarities. The WMCE approach suggests that the most cost efficient strategy is used when the capacity is limited. Paper I demonstrated that a “lazy”, or cost efficient, strategy is used whenever possible. This cost efficiency thinking is often not included in memory models.

Inspired by a model for ease of language understanding (Rönnberg, 2003), we propose a generalization of the WMCE approach that includes face recognition in general. This system incorporates an interaction between (a) working memory in a traditional sense, as well as (b) long-term memory and (c) the perceptual input channels. The system is economic in the sense that it uses fast and automatic long-term memory processes, as long as nothing unexpected occurs, and “lazy” semantic strategies when possible. When an unexpected stimulus input is presented (in relation to the long-term memory representations) a mismatch will occur (Näätänen & Escera, 2000) that switches processing over to an explicit, controlled mode which is slower and less cost efficient. This explicit processing demands more working memory capacity. In the memory conjunction studies in this thesis, mismatches will occur less often in less demanding tasks. However, at the

same time as the working memory demands rise, fewer mismatches will be discovered. Thus, the “lazy” strategy of relying on facial features will be used to a higher extent.

To summarize, the WMCE approach includes two different working memory effects. Their internal strengths are determined by the working memory demands of the task in relation to the working memory capacity of the individual. The application of these findings to witness psychology and the use of photographs as cognitive assistance is discussed in the following sections.

Applications to Witness Psychology

The areas to investigate in this thesis have been chosen not only to be theoretically interesting, but also to have ecological relevance. Therefore, the following application sections are important to show that this thinking have come to practice.

It has been found that persons with learning disability are at a greater risk than the general population of being subjected to a broad range of crimes including robbery, personal theft, burglary, sexual assault, and physical assault (Brown, Stein, & Turk, 1995; Williams, 1995). It is, however, not common that persons with learning disability appear in court, and especially not when they are the victim of the crime (Gudjonsson, Murphy, & Clare, 2000; Green, 2001; Williams, 1995). The barriers to access justice is based on a vulnerability that is often based both in the power imbalance in the relationship to others and in the individuals' characteristics (Home office as described in Clare & Murphy, 2001). In the UK, an inquiry found that less than 20% of persons with learning disability subjected to crimes reported to the police. Those who did, did not feel that

they were treated seriously (Sharp as cited in Clare & Murphy, 2001). Williams (1995) speaks of a spiral where the police do not record crimes because they think that there will be no prosecution. The staff does not report to the police since they do not do anything about it, and the victims do not tell the staff because they say that the police will not help.

In the UK, persons with learning disability may be allowed special measures in court (Cooke & Davies, 2001). These include giving testimony on video, using another person as intermediary between the witness and the court to make the witness understand the questions and the court to understand the responses, using communication aids like signs or communication boards, and removal of wigs and gowns. The last one seems somewhat peculiar, but the intention is to make the witness less insecure by removing artifacts that the witness is not familiar with. A Swedish study (Cederborg & Lamb, in press) of real cases with children with learning disability in court showed that they were expected to provide the same sort of reports as other children.

The type of questions asked is important for accuracy and completeness of eyewitness testimony for eyewitnesses in general, but especially for persons with learning disability (Cederborg & Lamb, 2006; Kebbel & Hatton, 1999). The more specific, leading or complex the questions get, the responses become more complete but less accurate (Kebbell, Hatton, Johnson, & O'Kelly, 2001). These settings are more problematic for persons with learning disability in three particular ways. First, they have a higher tendency to confabulation (Kebbell et al., 2001), that is, filling up gaps in memory with fabrications. Secondly, they have a higher tendency to suggestibility (Kebbell et al.), that is, they are providing the answer that they think the questioner wants to hear. Third, they have a higher tendency of

acquiescence (Sigelman, Budd, Spanhel, & Schoenrock, 1981), that is, they are more likely to say “yes” than “no” to yes-or-no questions.

In an investigation of real cases with persons with learning disability as witnesses at court (Kebbell et al., 2001), it was found that the problematic questions of the lawyers could be divided into two groups: questions that were leading; and questions that confuses the witness, like the use of double negativity, multiple questions and questions of complex vocabulary or semantic structure. It has been shown that witnesses with learning disability were able to answer questions with complicated structure if they were rephrased in a simple way (Kebbell & Giles, 2000; Kebbell & Johnson, 2000).

In our research, face recognition has been carried out in a way that has similarities with identifying a perpetrator. There are, however, many differences as well. Laboratory studies are performed under completely different circumstances compared to reality-based studies. Further studies have to investigate if the findings from this thesis can be used to suggest some implications for how to investigate crime experiences when persons with learning disability are suspected crime victims.

With these caveats in mind, the thesis suggests that high demands on working memory are associated with lower ability to discriminate between old and new pictures. Moreover, high working memory demands do not just lower the ability to recognize studied faces, but also increases the amount of false alarms. This is not true only for the persons with learning disability, but also for the controls. Actually, the controls with high working memory demands perform in a similar way to the learning disability group in tasks with lower working memory demands. This suggests that working memory demands at the time of the crime could be an important factor when

understanding how accurate a report is. This means that the number of persons and details to remember could be important as well as if the witness did something else at the same time.

The results in the papers included in this thesis show that persons with learning disability have particular problems with lures that include features that have been studied. Only facial features have been investigated here, but other studies have shown binding effects with shapes and colors (Zimmer & Steiner, 2003). Even though persons with learning disability were not investigated there, it can be assumed that that type of binding occurs for persons with learning disability too. Hence, it is possible that features like hair colors and nose shapes from different persons can be mixed up. These types of errors are common in recognition, but at recall they are present at a lower degree if present at all. Thus, free recall procedures is probably preferable instead of recognition procedures for persons with learning disability.

The similar performance for the controls and the learning disability group at different working memory demands suggests that persons with learning disability can be good and reliable witnesses given that the working memory demands are low.

Applications to the Use of Photographs as Cognitive Assistance

Paper I found that familiarity aids recognition, especially for familiarity of persons. It is also easier to understand what the photograph means in settings where a personal relation or experience to what is depicted exists. Together, this implies that photographs depicting things and situations with a personal experience should be used when possible.

It was also found that the associations between the depicted person and environment could be absent, present or implausible, where pictures with present associations were the easiest to recognize. This should have implications for how photographs can be organized for persons with learning disability.

Photographs with a present association between the person and the environment could be in the same folder without creating much recognition problems. However, for pictures with absent or implausible associations, it is more important to organize the pictures in a way where the user can see and understand which contexts the pictures are taken in. One way of creating this context could be to organize these types of picture by situation. Each folder could also be made unique by having an icon that shows something unique for this situation. If the pictures are organized by situation, the other pictures in the folder also give the context to prevent similar pictures from another context to be chosen.

Disability Research

A critical realist perspective (cf. Bhaskar, 1997) of disability research (Danermark, 2003) means that the reality is stratified in different levels of description of explanation, which cannot be reduced to any of the others. Rönnerberg (2005) describes three different levels of description of explanation: the perceptual level, the cognitive level, and the social level. He also introduces two types of integration of knowledge in disability research, horizontal and vertical.

Vertical integration concerns one concept at several levels. One good example is the case of GS (Rönnerberg, 1993, 2005). GS is deaf but uses a method for speech understanding that is called tactiling. It means that GS

uses his hand to pick up vibrations from the collarbone combined with visual information like lip reading. At the perceptual level the ability to perceive vibrations and visual information is important. GS has a high working memory capacity which helps him to process and understand the perceptual information at sufficient speed at the cognitive level. At the social level, conversational strategies for being able to put his hand at the collarbone of another person in a socially acceptable way are important, but working memory demanding. Again, conversational and perceptual strategies may be bound together through the use of the concept of working memory.

The horizontal perspective means that one theoretical concept is analyzed at one level in different populations. Things learned in one population can be implemented in the theory of another population and be further applied. A good example of a horizontal perspective is an investigation of the concept of theory-of-mind for children with DAMP, children with autism, children with asperger syndrome, and non-vocal cerebral palsied children (Dahlgren, Dahlgren Sandberg, & Hjelmquist, 2003). It was shown that problems with theory-of-mind was not specific to the autism spectrum, but could also be found in other groups with communicative disabilities. Conceptual development may therefore seek social rather than previously believed neural explanations (Rönnerberg & Melinder, in press).

This thesis has applied a vertical perspective to disability research. The analyses have been made at a psychological level, but implications for the social level have always been borne in mind when choosing areas to study. This is also evident in this thesis where applications for witness psychology and the use of photographs as cognitive assistance are discussed. Therefore,

the research conducted in this thesis is disability research and not only psychological research as such.

Summary

This thesis has produced several findings that are interesting for different reasons. The main theoretical contribution is to face recognition. It has been found that working memory plays an important part in face recognition. A working memory approach is proposed. This includes two different effects of working memory at retrieval of pictures of faces: high working memory capacity is, firstly, associated with recognition of more facial features, and, secondly, recognition of more facial configurations. Both these effects can result in more or less recognized pictures dependent on the type of recognition picture. The internal relative strengths among the two different effects of working memory capacity are determined by the relation between the individual's working memory capacity and how much the task taxes working memory.

It is proposed in Paper III and developed in Paper IV and in this thesis that when the demands on working memory are high, persons tend to rely to a higher degree on feature-based recognition at the expense of the two other working memory effects.

This working memory conjunction error approach for face recognition comprises an interaction between working memory in a traditional sense, long-term memory and perceptual input channels. The approach is economic in the sense that fast and automatic long-term memory processes are used as long as nothing unexpected occurs, and "lazy" semantic strategies when possible. When an unexpected stimulus input is presented (in relation to the long-term memory representations) a mismatch will occur that switches

processing over to an explicit, controlled mode that is slower and less cost efficient.

It was also found that the performance for persons with learning disability in a task with low working memory demands was similar to the performance of the controls, with higher working memory demands in the task. They were similar in the sense that performance for all recognition types was at the same level and that the performance for all the recognition types correlated similarly with the working memory performance. This indicates that learning disability, at least in this type of recognition task, can be simulated by higher working memory demands in a population without learning disability.

This finding is discussed in relation to witness psychology. It is suggested that working memory demands in relation to working memory capacity could be an important factor in judging accuracy of a report. This also implies that persons with learning disability can give as accurate reports under ideal conditions, as persons without learning disability can give under conditions with high working memory demands. It should, however, be noted that the research was conducted in laboratory studies under completely different and controlled circumstances compared to reality-based studies. Therefore, these suggestions should be taken as suggestions of what could be investigated in real settings.

Some implications for the use of photographs as cognitive assistance were also suggested. Photographs depicting something familiar are easier to recognize. It is also easier to understand what the photograph means in settings where a personal relation or experience to what is depicted exists. Taken together, this implies that photographs depicting things and situations with a personal experience should be used when possible.

Photographs with a present association between the person and the environment could be organized in the same folder without creating much recognition problems. However, for pictures with absent or implausible associations, it is more important to organize them in a way where the user can see and understand which contexts the pictures are taken in. One way of creating this context could be to organize these types of picture by situation and having unique icons for each folder.

Doing research on persons with learning disability demands methodological accuracy combined with creativity. The experiences made in the studies included in this thesis have lead to a proposal that also could be used for other populations. First, the abilities needed to manage a task should be analyzed. Then, tests should be constructed with gradually raised demands on abilities to minimize threats to making nonvalid interpretations. For example, in Paper I, picture recognition was investigated for pictures including pictures of the participant himself or herself. Tests of the ability to recognize oneself and tests of being able to match identical pictures were used to make sure that the interpretation of the recognition task did not depend on a lack of those cognitive abilities.

Future Research

Directions for future disability research may encompass a vertical or a horizontal perspective. With a horizontal perspective in mind, a comparative study of memory conjunction errors is proposed. In particular, groups with different working memory capacities would be interesting to study with different working memory demands of the tasks. This would further deepen our knowledge of the relationship between working memory and memory conjunction errors.

A study with a vertical perspective is also proposed. It should investigate working memory more in detail with measures of all the components in the Baddeley (2000) model of working memory, and relate those to memory conjunction errors. This relation should also be investigated at the social level in an applied setting of witness psychology.

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