PICTURES AND A THOUSAND WORDS –
LEARNING PSYCHOLOGY THROUGH VISUAL
ILLUSTRATIONS AND TESTING

Ann-Sofie Jägerskog
Pictures and a Thousand Words
Learning Psychology Through Visual Illustrations and Testing
Ann-Sofie Jägerskog
”There is nothing in our understanding that was not before in the sense.”

Johan Amos Comenius

To Isak, Moa and Olivia
Abstract

For teachers and students to be able to make informed decisions about how to best improve learning, it is important to compare learning strategies that are known to be effective. Both multimedia learning, based on the notion that individuals learn better from words and pictures presented together than from words alone, and retrieval practice, based on the idea that retrieving knowledge from the memory is an active process that has a beneficial impact on learning, have been found robust learning strategies in earlier research. However, the two strategies remain to be investigated in combination. The combination of the two seemingly robust strategies was investigated in Study I and results showed a modest effect of retrieval practice in terms of decreased forgetting and a strong effect of multimedia learning. Retrieval practice did not improve memory performance beyond the beneficial effect of using a visual illustration. Study II investigated the beneficial effects of the use of visual illustrations in more detail in terms of preferred learning style (visual, verbal or mixed), a notion that has reached wide popular acceptance within the educational field. Support was not found for the learning styles hypothesis. Rather, results showed that the positive effects of learning with the aid of a visual illustration holds independently of preferred learning style, which renders strong support for multimedia learning in terms of its generalizability. Most interestingly, students with mixed or visual learning styles performed generally better on the learning test than students with a verbal learning style, which may imply that it is worthwhile to help students develop a preference for visual or multimodal aspects of information processing in order to further improve learning. The findings presented in this thesis provide new knowledge regarding the combination of learning strategies and contribute with important insights into the relation between learning style and the use of visual illustrations in psychology teaching. The findings also pose challenges for students and teachers, as well as people designing learning materials, concerning how to approach the use of visual illustrations and retrieval practice in teaching and learning.

Keywords: learning, multimedia learning, retrieval practice, testing effect, visual illustration, learning styles, visualiser, verbaliser.
Sammanfattning

För att lärare och elever ska kunna fatta väl grundade beslut i arbetet med att skapa goda förutsättningar för lärande är det viktigt att jämföra lärstrategier som har visat sig vara effektiva. Två lärstrategier som i tidigare forskning visat sig vara robusta är användandet av visuella illustrationer, baserat på idén att människor lär bättre från ord och bild kombinerat än från enbart ord, och användandet av minnestestning, baserat på idén att framplockning av kunskap från minnet är en aktiv process som gynnar lärandet. Dessa två lärstrategier har dock inte studerats i kombination tidigare. Det övergripande syftet med denna avhandling var att bidra till förståelsen kring vilken påverkan användandet av visuella illustrationer och minnestestning har på lärandet i psykologi, för att på så sätt kunna dra slutsatser kring möjliga konsekvenser för psykologiundervisningen på gymnasiet. Kombinationen av de två lärstrategierna undersöktes i Studie I och resultaten påvisade en stark positiv effekt på lärandet av användandet av visuell illustration och en viss positiv effekt av minnestestning. Minnestestning bidrog dock inte ytterligare till lärandet utöver den positiva effekten av en visuell illustration. I Studie II undersöcktes de positiva effekterna av användandet av en visuell illustration i undervisningen närmare i termer av lärstil (visuell, verbal, eller mixad), ett begrepp som har vuxit sig starkt inom skola och utbildning. Resultaten påvisade inget stöd för lärstilhypotesen, men visade däremot att de positiva effekter som användandet av en visuell illustration har i en lärsituation gäller oberoende av vilken lärstil man föredrar. Detta påvisar starkt stöd för multimedia-principen och dess generaliserbarhet. Elever med visuell eller mixad lärstil presterade generellt sett bättre på lärandetestet än elever med en verbal lärstil, vilket skulle kunna betyda att det är värt att hjälpa elever att utveckla en preferens för visuella eller multimodala aspekter av informationsprocessande för att ytterligare förbättra förutsättningarna för lärande. Resultaten som presenteras i denna avhandling bidrar med ny kunskap kring kombinationen av de två lärstrategierna, liksom med viktiga insikter kring relationen mellan lärstil och användandet av visuella illustrationer i psykologiundervisningen. Resultaten innebär utmaningar för både lärare, elever och personer som arbetar med att ta fram läromedel, kring hur man kan använda visuella illustrationer och minnestestning i undervisning och lärande.
Someone resembled writing a thesis with running a race and I couldn’t but agree. Sometimes it is downhill and the legs keep going without too much effort. At other times there are steep hills to be climbed and doubts concerning the capacity to climb them arise. The cheering of people around then becomes invaluable, as well as people offering refreshment stations along the way. Also, running partners become ever so important in helping to keep going and believing that the goal is within reach. I have been blessed with many wonderful running partners, great coaches as well as many cheering friends along the way, and for this I am enormously grateful.

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Ann-Sofie Jägerskog

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List of Studies

The present thesis is based on the following studies:


## Contents

Abstract .......................................................................................................................... vii  
Sammanfattning ........................................................................................................... ix  
Acknowledgements ....................................................................................................... xi  
List of Studies ............................................................................................................... xiv  
Abbreviations ............................................................................................................. xvii  
Introduction .................................................................................................................. 2  

### Learning
- Learning as a cognitive process ........................................................................... 4  
- Measuring learning: Recall and transfer ......................................................... 5  
- Learning and instruction as a subject-specific domain ....................................... 6  
- Learning in the classroom and the laboratory ................................................... 6  

### Multimedia learning
- Defining multimedia learning ............................................................................... 8  
- Cognitive theory of multimedia learning ....................................................... 9  
  - Dual channels assumption ............................................................................. 10  
  - Limited capacity ......................................................................................... 11  
  - Active processing ....................................................................................... 11  
- Reasons for the usefulness of visual illustrations ........................................... 12  
- Visual illustration ............................................................................................... 12  
  - Different functions of a visual illustration .................................................. 12  
  - What characterizes a good visual illustration? ............................................. 13  
  - Visual illustrations in subject-specific domains ......................................... 14  
- Related aspects: Visual literacy and mental imagery ........................................ 15  

### Retrieval practice
- Memory as an active process .............................................................................. 17  
- How does retrieval practice affect learning? ................................................... 18  
  - The testing effect ....................................................................................... 18  
- Factors affecting the impact of retrieval practice on learning ......................... 20  
- Why does retrieval practice affect learning? .................................................. 20  
- Retrieval practice in subject-specific domains .............................................. 21
Abbreviations

CTML = Cognitive Theory of Multimedia Learning
SOP = Style of Processing
VVQ = Verbaliser – Visualiser Questionnaire
Introduction

Illustrations do not merely function as a decorative complement, but can, as suggested by Brody (1982), create motivation, explain difficult concepts, expand the understanding and affect the cognitive processes involved in learning. Many working within education would probably agree that pictures and visual illustrations have the potential to significantly contribute in different learning situations (Peeck, 1993). The notion of people learning better from pictures and words combined than from words alone is known as the multimedia effect (Mayer & Moreno, 1998). However, verbal learning (auditive or written) has dominated education, and so educational research has primarily come to focus on verbal learning (Danielsson & Selander, 2014; Mayer, 2010b; Stokes, 2002; Tønnessen, 2009). The potential value of visual illustrations in a learning context may be generally acknowledged and an increase of visual illustrations can be seen in the society in general as well as in educational materials (Kress, 2003; Peeck, 1993), but how well does the use of a visual illustration work in comparison to other learning strategies, and for whom does it work?

Many educators would also agree that testing is an unavoidable part of education. Testing is often used at the end of a term or a course element, for the purpose of summative assessment and is often assumed to be a relatively neutral event in the learning process (Karpicke & Roediger, 2007). Research shows that testing, or retrieval practice, can be used in order to enhance learning and is accordingly not limited to assessment only (Dunlosky, Rawson, Marsh, Nathan & Willingham, 2013; Gates, 1917; Karpicke & Roediger 2007; Rawson & Dunlosky, 2012; Spitzer, 1939), but few studies have investigated how well this effect stands in relation to other effective learning strategies, such as multimedia learning.

Many educators argue for the importance of taking individual factors into consideration in a learning situation. During the last decades, the notion of learning styles, that is, individual preference for how one best learns, has reached wide acceptance in many schools (Riding & Cheema, 1991). Despite being vastly recognized within education, research on learning styles and its usefulness is rather unclear (Pashler, McDaniel, Rohrer & Bjork, 2008; Riding & Cheema, 1991). For instance, does individual learning style
affect the impact of multimedia learning, or is the impact of a visual illustration independent of individual learning style?

In the Swedish Educational Act (SFS 2010:800) it is stated that education should be based on scientific knowledge and proven experience. In the present thesis I intend to contribute with one small piece to the complex jigsaw of creating an evidence-based teaching. The overall aim was to contribute to the understanding of the possible impact of visual illustrations, learning styles and retrieval practice (i.e., memory testing) in learning psychology. Both retrieval practice and the use of visual illustrations have been found robust learning strategies in earlier research, but the two learning strategies remain to be tested in combination in the same study. In everyday teaching, many different learning strategies are used in combination and it is important for teachers as well as students to be able to make informed decisions about how to best improve learning. However, surprisingly few studies have investigated the relative efficacy of different robust strategies. Study I focuses on the comparison and combination of multimedia learning and retrieval practice. Study II looks into possible individual aspects of the impact of visual illustrations on learning in terms of verbal versus visual learning style. Further, the studies were carried out in an authentic classroom environment, using a material based on content from the social sciences (psychology) and with a longer retention interval (one week and ten weeks). Much previous research on multimedia learning and retrieval practice has been conducted in laboratory settings and/or with the computer as the learning tool, based on materials from science and mathematics and with shorter retention intervals.

In the following sections I first present and problematize learning as a concept. I then give an overview of the three main areas covered in this thesis; multimedia learning, retrieval practice and learning styles. Next, I present a summary of the two studies included. Finally, I discuss the findings, possible implications for education and suggestions for future research.
Learning

Central to the science of learning is how people learn and what aspects should be taken into consideration in order to understand learning (Mayer, 2009). However, the answers will differ depending on the view taken on learning and how learning is interpreted (Selander, 2009). The learning context, interaction between individuals and situational aspects are all of importance when discussing the learning process (Säljö, 2011). In this work the complex phenomenon of learning is studied in terms of a cognitive process.

Learning as a cognitive process

Learning from a cognitive perspective can, on the one hand, be considered information acquisition and, on the other hand, knowledge construction (Mayer, 2009). The two views result in different ways of considering knowledge, learning and teaching. In the first perspective, learning is considered to add information to memory and knowledge thus becomes an objective that can be moved from place to place. The learner becomes a passive receiver of information and the teacher’s job is to present it. Accordingly, the goal of teaching is to deliver information as efficiently as possible. In contrast, the second view considers knowledge as personally constructed by the learner, who is an active sense-maker, trying to organize and integrate new material into a coherent mental representation. The teacher’s job thus becomes to help the learner in this process and the learning outcome is considered dependent on the cognitive activity during learning rather than the behavioural activity in the learning situation (Mayer, 2009).

Learning can, from the viewpoint of multimedia learning, be considered “a change in knowledge attributable to experience” (Mayer, 2009, p. 59), implying that learning always involves a change in what one already knows. This definition involves three aspects: (1) learning involves a change, (2) what is changed is the learner’s knowledge, (3) the change is caused by the learner’s experience in the learning environment (Mayer, 2009). From a retrieval practice perspective, more emphasis would be given to the retrieval process as an explanation to the change in knowledge rather than on the learner’s experience in the learning environment (Karpicke, 2012). A change
in knowledge does not simply imply adding new knowledge, but rather reorganizing, integrating and elaborating knowledge (Karpicke, 2012; Mayer, 2009). With this knowledge construction view on learning, the learner’s active cognitive processes in a learning situation, involving both encoding as well as retrieval processes, are crucial for what is actually learnt and how well it is learnt (Karpicke, 2012; Mayer, 2009). The present thesis is based on the knowledge construction view on learning.

Measuring learning: Recall and transfer

To learn something involves at least two different aspects: remembering and understanding, aspects often referred to as recall and transfer (Mayer, 2009). Mayer (2009) suggested that, in order to reach meaningful learning, both recall and transfer aspects need to be taken into account. Mayer (2009) defined recall as the ability to reproduce or recognize previously presented material. Transfer has been defined in slightly different ways and is not a unitary phenomenon (Salomon & Perkins, 1989). It has been defined as the ability to use presented material in different contexts or situations (Mayer, 2004), as a novel demonstration of learning (Rohrer, Taylor, & Sholar, 2010), as an application of knowledge (Carpenter, 2012), as solving novel problems based on the material learnt (Butler, 2010; Johnson & Mayer, 2009) and as displaying learning on some other occasion, however similar (Salomon & Perkins, 1989).

Because learning is an internal process, it cannot be directly observed. Instead, one needs to look for indices of learning, or performance (Soderstrom & Bjork, 2015). In research as well as in school situations, learning indices often consist of a change in the learner’s behaviour, achievement, ways of expressing thoughts, or performance on a test (Hattie, 2009; Mayer, 2009; Soderstrom & Bjork, 2015). However, as Hattie (2009, p. 249) suggested, "Knowing is an activity, not a thing /…/ and it is not easily objectively defined by a one-off test." Nevertheless, learning needs to be measured in school situations as well as in research.

In multimedia and in retrieval practice research recall as well as transfer tests are being used in order to measure learning. Recall tests often consist of open-ended free recall questions, where students are asked to recall everything they can remember from the content learnt, or recognition tests, where students are asked to select what was presented (e.g., multiple-choice questions; Mayer, 2009). Transfer tests measure the learner’s ability to apply the presented material to a new or different situation, such as solving related problems not explicitly mentioned in the presented material (Mayer, 2009). Mayer (2009) has suggested four kinds of transfer questions, in different
aspects measuring this ability: (1) redesign questions, where the learner is asked to modify the content involved, (2) troubleshooting questions, where the learner is asked to describe possible problems in relation to the content learnt, (3) prediction questions, asking the learner to predict something on the basis of the content learnt, and (4) conceptual questions, asking the learner to reveal an underlying principle connected to the presented material.

In the present work, both free recall and transfer tests were used to measure learning. Free recall was used as previous research suggests that this kind of recall promotes learning more than for instance cued recall (Roediger & Karpicke, 2006a). A transfer test based on Mayer’s (2009) different kinds of transfer questions was used in order to grasp different aspects of transfer. Transfer is in the present work defined similarly to Salomon & Perkins (1989, p. 5), who talked about it in terms of the “effect of learning something on a different performance or context”. However, focus in this work is on a different performance rather than context.

Learning and instruction as a subject-specific domain

Several researchers have argued that learning should also be viewed in relation to its subject-specific content, because learning may be domain-specific rather than domain-general (Caillot, 2007; Mayer, 2004; Shulman, 2004b; Shulman & Quinlan, 1996). Likewise, Pashler and colleagues (Pashler, Cepeda, Wixted & Rohrer, 2005) suggested that what is optimal instructional methods may vary across different disciplines. Also, Mayer (2004, p. 716) has suggested that “research on the psychology of subject matter shows the benefits of building a science of instruction that is contextualized in school subjects rather than presented as general context-free principles”.

Much progress has been made over the past 20 years in research on subject matter and the development in this area has been acknowledged as one of the main accomplishments of educational psychology (Mayer, 2004, 2011). However, there is a need for more research related to each kind of subject matter in order to extend the understanding, for teachers as well as students, of what teaching tools and learning strategies are best suited for each subject matter (Pashler et al., 2005).

Learning in the classroom and the laboratory

Learning has been studied in laboratory settings as well as in more applied settings (Bangert-Drowns, Kulik & Kulik, 1991; Herrlinger, 2012; Leeming, 2002; McDaniel, Anderson, Derbish & Morrisette, 2007; Moreno & Valdez, 2007; Ozcelik, Arslan-Ari & Cagiltay, 2010; Roediger, Agarwal, McDaniel
However, it is important to be aware of the many differences between a laboratory setting and a classroom setting. For instance, such differences include the amount of knowledge the students are expected to learn, the various ways a to-be-learnt material is presented in a classroom, how much study time is spent before an exam, the students’ motivation to learn, their interest in the material, etc. (Koriat & Goldsmith, 1996; Roediger & Karpicke, 2006a).

A concern among many psychologists is to what extent laboratory findings generalize to more applied situations (Roediger & Karpicke, 2006a; Schwartz & Eklides, 2012). For instance, many of the principles that underlie advice to teachers concerning memory, is based on laboratory research, using for instance recall of wordlists presented under strictly controlled conditions (Miller, 2011). This approach is well suited for exploring how the cognitive system works, but may not adequately reflect a more applied classroom setting, since a classroom in many respects is more complex than a laboratory setting (Miller, 2011). To inform about the practical application in educational settings it is therefore important to investigate aspects of learning in both laboratory settings and authentic learning situations in the classroom (Mayer, 2010b). To add to the research and to provide advice for teachers, based on studies in an authentic context, the present work is conducted in an applied classroom setting.
Multimedia learning

People learn better from words and pictures presented together than from words alone (Paivio, 1986; Mayer, 2011). This proposal, which is often referred to as the multimedia instruction hypothesis, is the core of multimedia learning (Mayer, 2011; Schnotz, 2010). The hypothesis suggests that a visual illustration in combination with a verbal presentation has the potential to improve retention as well as problem solving transfer (Mayer, 2010b) and is referred to as the multimedia effect (Mayer & Moreno, 1998). Accordingly, connecting words and pictures is suggested to create a deeper understanding of a presented material than words only (Mayer, 1997). As emphasized by Danielsson and Selander (2014) as well as Selander (2009), pictures or visual illustrations should not be considered as solely adding something to the text, but as a different means of communication, focusing certain aspects and details of the material to be learnt.

The multimedia effect has been replicated in both laboratory and classroom settings as well as with different study material, such as lightning formation (Johnson & Mayer, 2009; Mayer, Bove, Bryman, Mars & Tapangco, 1996), car break systems (Mayer & Anderson, 1992; Mayer & Moreno, 1998), animal behaviour (Harskamp, Mayer & Suhre, 2007), cellular transportation (Rundgren & Tibell, 2009) and teaching principles (Moreno & Valdez, 2007). Carney and Levin (2002) concluded that a visual illustration can be an aid in learning, in terms of perceiving as well as understanding and remembering the to-be-learnt material.

Despite a seemingly robust multimedia effect in earlier research (Mayer, 2011), there are studies that fail to find a general multimedia effect, for instance in regard to primary school children (Herrlinger, 2011) and in learning content from the social sciences (Westelinck, Valcke, De Craene & Kirschner, 2005). In the present work, multimedia learning is examined further with material from the social sciences and is seen in comparative terms to two areas that have gained increasing interest over the last decades: retrieval practice and learning styles.
Defining multimedia learning

Theories on multimodal learning emphasise the fact that when communicating, we use several different semiotic resources, or semiotic modalities, such as written or spoken language, colours, graphic design, pictures and gestures (Danielsson & Selander, 2014). In the present work I focus on one such semiotic modality, namely pictures in terms of a visual illustration. Including a visual illustration when learning or communicating a message or subject content is often referred to as multimedia learning and is in the present work, and in line with Mayer’s (2010b) description, defined as presenting or learning something with both words and pictures. Words are in this context considered material presented in verbal form and is expressed either in written text, or through spoken words. Pictures are material presented in pictorial form as either static graphics, such as drawings, illustrations, maps, tables, diagrams, charts and photos, or as dynamic graphics, such as animations (Mayer, 2010b). Theories of multimedia learning also focus on the learning process, including building mental representations from both words and pictures (Mayer, 2010b; Schnotz, 2010; Sweller, 2010). Accordingly, multimedia instruction involves presenting a material through both words and pictures in order to help individuals create such mental representations (Mayer, 2010b).

Schnotz (2010) presented three different views on the term multimedia. First, the delivery-media view, where focus is on the actual media, such as computers, white boards, and projectors, used to present the content. Second, the presentation-modes view, where focus is not on the delivery devices, but on the mode in which the material is presented, for example, through words or pictures. Third, the sensory-modality view, where focus is not on the mode used to present the material, but the senses used when receiving the content, such as auditory and visual senses. Whereas the first view focuses on the devices, the other two are learner-centered, since they take the information-processing activity into account (Mayer, 2009; Schnotz, 2010). The present work takes its starting point in the two learner-centered aspects of multimedia.

Cognitive theory of multimedia learning

The basis of the cognitive theory of multimedia learning (CTML) is that in order to facilitate meaningful learning, multimedia instruction needs to be designed in relation to how the human mind works, that is how individuals learn (Mayer, 2010b). The aim of CTML is to explain how knowledge is constructed from words and pictures and is based on three assumptions: dual channels, limited capacity, and active processing (Mayer, 2010a). As seen in
Figure 1, CTML also draws upon theories in memory in connecting different cognitive processes to memory stores, such as sensory memory, working memory and long-term memory (Herrlinger, 2011).

Dual channels assumption

According to the dual channels assumption there are separate channels for processing words and pictures (Mayer, 2011; Mayer & Sims, 1994). The idea of two separate channels for information processing is not new in cognitive psychology and is closely associated with Paivio’s dual coding theory (Paivio, 1986) and Baddeley’s working memory model (Baddeley, 1992). Mayer (2009) suggested two ways of describing the differences between the two channels. First, the distinction could be made on the basis of presentation mode: if information is given verbally or nonverbally. Second, it could be made on the basis of sensory modality: if the learner is initially processing the information through their eyes or ears. The first distinction focuses on the format of the material presented and is most consistent with Paivio’s (1986) ideas, whereas the second distinction focuses on the format of the material as represented in the working memory and is therefore most consistent with Baddeley’s (1992) ideas. The major difference between the two views relates to the interpretation of written words. In the presentation mode view, it is considered verbal, whereas in the sensory modality view it is considered visual, as it is processed through the eyes. Mayer (2009) suggested that the two views may be merged in that the presentation mode approach could be useful in distinguishing between verbally and pictorially based models in working memory, whereas the sensory modality approach could be helpful in distinguishing between visually and auditorily presented material.
An assumption connected to the idea of dual channels is that information can be processed in both channels. Information that initially was processed in the auditory channel will also be processed in the visual channel when the learner creates a corresponding mental image, and vice versa (Mayer, 2009).

In the present work, I focus on presentation mode, rather than sensory modality, since students are presented the material only verbally or verbally combined with a visual illustration.

Limited capacity
The second assumption in the CTML states that the two channels are limited in terms of the amount of information that can be processed at the same time. The idea of limited processing capacity has a long history in psychology and is closely related to for instance Sweller’s cognitive load theory (Sweller, 2010) and Baddeley’s theory of working memory (Baddeley, 1992). The idea behind limited capacity is that too many elements can overwhelm the working memory, causing a decrease of the effectiveness of a visual illustration (Kalyuga, Chandler & Sweller, 1998). The limited capacity forces a learner to decide what information to pay attention to and what connections to be made between the information and already existing knowledge (Mayer, 2009). When developing multimedia instruction, this assumption should ideally be taken into consideration.

Active processing
The third assumption suggests that we actively engage in cognitive processing during learning (Mayer, 2011). Three processes are essential for active learning: selecting relevant material, organizing the material selected and integrating the selected material with prior knowledge, as illustrated in Figure 1 (Mayer, 1997, 2009; Mayer & Moreno, 1998). The selecting process involves paying attention to relevant words and pictures and thereby choosing what part of the material to be learnt we will continuously process (Mayer, 1997). Organizing involves creating coherent mental representations from the selected words and pictures and the integrating process implies the building of connections between the new verbal and pictorial mental representations and already existing knowledge (Mayer, 2009; Mayer & Sims, 1994). Mayer (2009, 2011) suggested that meaningful learning is reached when all those processes are activated in the learning process and that multimedia design aims at assisting learners in this process.
Reasons for the usefulness of visual illustrations

At least three reasons for the beneficial effect of visual illustrations in learning situations have been suggested. First, a visual illustration can produce motivation, generate excitement and focus attention (Brody, 1982; Peeck, 1993), which is thought to enhance learning. Second, a visual illustration is suggested to help clarifying and interpreting content that is hard to comprehend (Peeck, 1993) and function as a support to reasoning and problem solving, in that it visualises abstract concepts and stimulates new ways of thinking (Carney & Levin, 2002; Moreno, Ozogul & Reisslein, 2011; Pauwels, 2000, 2006; Peeck, 1993; Rundgren & Tibell, 2009). Levin and Mayer (1993) suggested that the more complex a content is, the more likely it is that the illustration is helpful in creating an understanding. Third, and as suggested in the CTML (Mayer, 2010a), a visual illustration contributes to creating mental models (Hegarty & Just, 1989; Mayer & Gallini, 1990; Seel & Strittmatter, 1989) and induces more elaborate processing (Peeck, 1993). As such, an illustration can function as mental scaffolding (Fang, 1996), help establish non-verbal codes alongside the verbal (Kulhavy, Lee & Caterino, 1985) and generate a greater distinctiveness at encoding the material concerned (Rusted, 1984).

Visual illustration

Different functions of a visual illustration

There are several different kinds of visual illustrations and they will affect learning to various extents and in different ways (Carney & Levin, 2002; Levin, 1981). Levin (1981) suggested five different functions of a visual illustration, generating different beneficial text-picture effects: (1) purely decorative function without being related to the content, (2) representational function, illustrating part of the text and common in story books, (3) organizational function, providing a “framework” to organize the text, (4) interpretational function, helping to clarify a complex content, and (5) transformational function, providing recoded content knowledge, designed to improve recall. As noted by Carney and Levin (2002), many multimedia studies use visual illustrations with an interpretational function, in order to make a complex learning content more comprehensible (e.g., Kartal, 2010; Mayer & Anderson, 1992; Mayer et al., 1996; Mayer & Moreno, 1998; Rundgren & Tibell, 2009).

In the present work the visual illustration used is a static graphic, illustrating the Atkinson-Shiffrin memory model (Atkinson & Shiffrin, 1968), out-
lining the flow from sensory memory, to short-term memory and to long-term memory, with boxes and arrows combining them. This subject content in the psychology course is rather abstract and complex and can therefore be considered well suited for the use of a clarifying and interpretational visual illustration. Accordingly, visual illustration is in the present work limited to its interpretational function.

What characterizes a good visual illustration?

Literature on visualizations shows the need to consider the design of a visual illustration, since not all illustrations are equally effective (Mayer, 2010b; Rundgren & Tibell, 2009). Indeed, if a visual illustration is designed in a non-efficient way, it can rather create difficulties in the learning situation (Kalyuga et al., 1998; Moreno et al., 2011; Rundgren & Tibell, 2009; Schönborn, Anderson & Grayson, 2002). Levin and Mayer (1993) emphasised different aspects to take into consideration when creating a visual illustration in order for it to be an aid in the learning process, such as the importance of concision (unneeded details or colours are reduced), concretion (illustrations are presented so that it can be easily seen) and coherence (the material presented has a clear structure).

In resemblance to the aspects mentioned above, more detailed principles for the design of visual illustrations have been formulated in order for the illustrations to manage essential processing and reduce extraneous processing in multimedia learning (Mayer, 2009, 2011). One such principle is the segmenting principle, stating that individuals learn better when being presented the material to be learnt in segments rather than as a continuous unit. The coherence principle underlines the importance of reducing extraneous words or graphics, linking to the signalling principle suggesting that essential words and graphics should be emphasised. Also, as suggested in the spatial contiguity principle, essential words should be placed near the corresponding graphics. There is also a principle suggesting that a visual illustration presented together with spoken words is better than presented with printed words, known as the modality principle. The visual illustration used in the present work is created according to the principles mentioned above.

Apart from the design of a visual illustration, other aspects such as prior knowledge, the expertise of the learner and individual differences, such as spatial ability, may also affect the impact of a visual illustration on learning (Cook, Carter & Wiebe, 2008; Kalyuga et al., 1998; Mayer, 1997; Mayer & Sims, 1994). However, studies focusing on the effects of different presentation formats in teaching often fail to take learners’ individual differences into account (Kollöffel, 2012). Study II looks into the relation between multimedia learning and visual/verbal learning style. More specifically, I investigate whether psychology teachers should focus on individual differences in terms
of students’ preferred learning style, or put their efforts into a more general multimedia learning strategy.

Visual illustrations in subject-specific domains

The use of visual illustrations in science education has received further attention in recent years (Rundgren & Tibell, 2009) and visual illustrations have become a common and natural part of teaching and learning in order to explain difficult and abstract concepts and deepen the understanding of certain content. During her studies in a chemistry laboratory setting, Kozma (2003) concluded that:

“The first thing we noticed was that representations were everywhere in these laboratories. Structural diagrams and equations were /.../ written on glass hoods and white boards throughout the lab. And they were in notebooks and reference books, and in journal articles and advertisements on bookshelves and bench tops.” (p. 209)

In other subject domains, visual illustrations are not as frequently used, or are rather used as decorative or motivational ingredients. Pauwels (2000) argued that there is a current dominance of camera image in the social science. Walking into a social sciences classroom does often not involve the many visual illustrations and representations as described by Kozma (2003) above. Westelinck and colleagues (2005) even suggested, based on a study with 190 university students studying educational sciences, that the multimedia effect is not generally applicable in the social sciences. In contrast to the natural sciences, they argue, the graphical representations in the social sciences are not built on a consensual iconic sign system previously acquired or mastered by the students. Further, they suggest that representations in the field of natural sciences are intuitive and depictive in nature, which often is not the case within the social sciences.

Much of the research on multimedia learning in educational settings has been conducted within the field of natural sciences and mathematics (Ozcelik et al., 2010; Seufert, Schutze & Brunken, 2009; Johnson & Mayer, 2009; Harskamp et al., 2007; Kartal, 2010), while less focus has been given to material from the social sciences (but see Westelinck et al., 2005; Herrlinger, 2011). Hence, the issue of multimedia learning in the social sciences needs further attention (Mayer, 2011). Mayer (2010b) pinpointed subject content as one boundary condition worth studying when it comes to multimedia learning and the material used in the present work is a memory model from the upper secondary psychology course.
Related aspects: Visual literacy and mental imagery

When discussing the role of visual illustrations in teaching and learning, there are two aspects worth mentioning, both related to the idea of multimedia learning: visual literacy and mental imagery, here described in brief.

First, improving learners’ visual literacy is considered to be one possible way of increasing the beneficial effect on learning when using visual illustrations in the learning situation (Peeck, 1993). An underlying idea is that a visual illustration is a valuable and legitimate source of information and that meaning and knowledge is built up through more modalities than just words (Peeck, 1993). Stokes (2002) defined visual literacy as the ability to interpret images as well as generate them for communicative purposes. Felten (2008) talked about it in terms of understanding, producing and using images and Wileman (as cited in Stokes, 2002) defined it as the ability to read, interpret and understand information presented visually. Stokes (2002) suggested that visual literacy is associated to visual thinking. The interpretation of images can be considered a specific language, since images are often used in order to communicate a message (Stokes, 2002). This message needs to be decoded in order to be understood and acquire meaning (Stokes, 2002). Accordingly, being literate involves more than simply understanding words and text (Kress, 2003). In this sense, visual literacy may be considered one of many literacies necessary to master (Kellner, 1998). However, visual literacy should not be considered a static skill, automatically mastered in an image rich society, but a skill that, similar to other skills, can be developed through practice (Felten, 2008; Stokes, 2002). Felten (2008, p. 60) suggested that “with practice, people can develop the ability to recognize, interpret and employ the distinct syntax and semantics of different visual forms”. Accordingly, the extent to which a visual illustration aids learning could partly be considered a question of practice.

Second, mental imagery is considered being involved in important cognitive functions such as memory and learning (Gyselinck & Pazzaglia, 2012; Kosslyn, Thompson & Ganis, 2006) and is often referred to as seeing with the “mind’s eye” (Kosslyn et al., 2006; Mast, Tartaglia & Herzog, 2012). For instance, if people were asked what they had for breakfast, many would produce a visual image of what was actually on the breakfast table (Kosslyn et al., 2006). This implies that images can be created in our minds even if the knowledge mentally viewed is not simultaneously perceived by the senses (MacIntyre, Moran, Collet & Guillot, 2013; Mast et al., 2012) and that mental imagery accordingly is not limited to visual modality (Kosslyn et al., 2006).
Research on mental imagery re-emerged with the work of Alan Paivio (1971), but despite several decades of empirical research, there are still several unclarities related to mental imagery, such as the nature of mental images and their relation to language (Gyselinck & Pazzaglia, 2012; Kosslyn et al., 2006). One of the main topics debated is what mechanisms underlie mental imagery (see for ex. Kosslyn, Ganis & Thompson, 2003). However, it has long been known (e.g. since Galton, 1883) that there are individual differences in reported imagery vividness and strength (MacIntyre et al., 2013; Rademaker & Pearson, 2012). Some people report intense and vivid images, whereas others report only limited details or even doubt the existence of mental imagery (MacIntyre et al., 2013; Rademaker & Pearson, 2012). There are no clear answers to why mental imagery differs largely between individuals (Rademaker & Pearson, 2012). However, one explanation suggested by several researchers is that actively practicing mental imagery, such as everyday activities involving strong use of mental images, can enhance its strength and vividness (Rademaker & Pearson, 2012). Accordingly, although results are slightly unclear, improvement of imagery strength may be possible through practice (Rademaker & Pearson, 2012).
Retrieval practice

Traditionally, testing is used in educational settings in order to measure learning and is often used at the end of a term or a course element as a tool for summative assessment (Roediger & Butler, 2011; Roediger & Karpicke, 2006b). However, research has shown that repeated memory testing during study, so called retrieval practice, also promotes learning (Dunlosky et al., 2013; Gates, 1917; Rawson & Dunlosky, 2012; Roediger & Karpicke, 2006b; Spitzer, 1939). Retrieval practice refers to memory testing as a learning strategy that often leads to better long-term learning than for example restudying, since the active process of retrieval has a beneficial impact on memory (Karpicke, 2012; Karpicke, Lehann & Aue, 2014). This implies that if the student during the initial learning is actively working with the material, that is producing rather than recognising or re-studying the material, it is better learnt (Schwartz, Son, Kornell, & Finn, 2011; Roediger & Karpicke, 2006a). The benefit of retrieval practice in favour of restudying is often referred to as the testing effect (Roediger & Karpicke, 2006a). Study I investigates this learning strategy in combination with another reliable learning strategy: multimedia learning. Both learning strategies have been found robust in earlier research, but remains to be investigated in combination, an aspect that would be of interests for teachers as well as students.

Memory as an active process

Memory has sometimes been considered a storage of knowledge, signalling a rather passive phenomenon (Karpicke, 2012; Koriat & Goldsmith, 1996). However, research suggests that memory involves considerably more than the mere storing of earlier acquired knowledge. Rather, memory can be defined as a mental activity, where both encoding, storing and retrieval processes are involved (Craik, 2002; Craik & Lockhart, 1972; Rowland, 2014). In learning, these different processes interact with each other in that the encoding of new material involves the retrieval of previous knowledge. Similarly, the retrieval of previously acquired knowledge can be seen as encoding, since retrieval involves elaboration and strengthening of the memory retrieved (Karpicke, 2012; Kubik, 2014). With this more active view on
memory, forgetting can be defined as an inability to retrieve knowledge previously learnt (Wixted, 2007), partly since the strength of a memory decays over time (i.e. decay theory, see for instance McGeoch, 1932).

How does retrieval practice affect learning?

The testing effect

The testing effect implies that there are clear benefits of retrieval practice when learning new material as compared to only restudying the material, since testing involves the active process of retrieving knowledge earlier learnt (Roediger & Karpicke, 2006b; Rowland, 2014). Tests may be used to improve student learning, not only assessing it, (Dunlosky et al., 2013). Karpicke (2012) suggested that retrieval is a key process to consider in order to understand learning, since knowledge is actively reconstructed when retrieved. Likewise, Halamish and Bjork (2011) suggested that testing should be considered an active learning event.

The positive effects of retrieval practice on memory has been shown with a variety of materials, such as word-lists (Bouwmeester & Verkoeijen, 2011), foreign language vocabulary or paired associates (Carpenter, Pashler, Wixted, & Vul, 2008; Jönsson, Hedner, & Olsson, 2012), prose passages (Roediger & Karpicke, 2006b), general knowledge facts (Butler, 2010; Carpenter et al., 2008), video lectures (Butler & Roediger, 2007), maps (Carpenter & Pashler, 2007) and visuospatial information (Kang, 2010). Such testing effect studies have often been conducted as experiments with an initial study session where participants study the to-be-learnt material, followed by a session where the material is either tested, re-studied or not worked upon at all. Students who are involved in retrieval practice normally remember more of the material learnt than students re-studying the material or not spending additional time on the material at all (Kornell, Bjork & Gracia, 2011). Accordingly, taking a memory test can improve learning more than restudying, since retrieving a to-be-learnt material enhances traces in memory more than re-encoding the same material (Bjork & Bjork, 1992; Karpicke & Roediger, 2007). Also, testing is suggested to reduce the forgetting rate of the material learned to a greater extent than restudying (Carpenter et al., 2008). The beneficial effect of retrieval practice is considered to improve further if the testing is repeated (Karpicke & Roediger, 2010). However, the positive effect of retrieval practice on learning, when given without feedback, is typically seen after longer retention intervals, but not necessarily on immediate recall tests (e.g., Roediger & Karpicke, 2006b; Toppino & Cohen, 2009). This means that there is typically an interaction between learning activity (retrieval prac-
tice or restudying) and retention interval (Roediger & Karpicke, 2006b). Retrieval practice has shown beneficial effects not only on recall, but also on transfer (Butler, 2010; Carpenter, 2012; Johnson & Mayer, 2009; Rohrer et al., 2010).

An additional benefit of testing is related to metacognition, in that retrieval practice helps the student to more accurately determine how much of the material actually has been learnt and what material needs more attention in order to be remembered (Nelson & Dunlosky, 1991). As a result, students can more easily spend an appropriate amount of study time and focus on areas not yet learned in order to improve their learning (Nelson & Dunlosky, 1991; Roediger & Karpicke, 2006a).

Retrieval practice has previously been investigated with multimedia material (Johnson & Mayer, 2009; Butler & Roediger, 2007; Kang, 2010; Carpenter & Pashler, 2007), but the testing effect remains to be tested together with the multimedia effect in the same study. Rather, most testing effect studies have compared testing to exact repetition, a learning strategy known to be ineffective. It is therefore of high relevance to study the two effects, both considered effective, together. For teachers and students to be able to make informed decisions about how to best improve learning, it is important to compare learning strategies that are known to be effective (see Kornell, Rabelo & Klein, 2012 and Roediger, 2013 for similar arguments). Study I investigates the combination of these two robust learning strategies in order to shed more light on and draw conclusions about their impact on learning.

**Two testing effects: the direct and the indirect testing effect**

Importantly, there is a distinction in the literature between direct and indirect benefits of testing (Karpicke et al., 2014). The direct testing effect refers to the benefits of retrieval practice when learning new material compared to only restudying the material. The indirect testing effect refers to effects mediated by subsequent events; tests are suggested to enhance subsequent re-encoding of earlier studied, but forgotten, knowledge (Arnold & McDermott, 2013). When given the opportunity to restudy the material after a test session (or when given feedback), students have a tendency to focus on knowledge that was not remembered during the test session (Kubik, 2014). In doing so, memory performance is enhanced and studying becomes more effective (Roediger & Karpicke, 2006a). In the present work, only the direct testing effect is focused upon and is accordingly referred to when the term “testing effect” is being used.
Factors affecting the impact of retrieval practice on learning

How much impact retrieval practice has on learning is dependent on several factors (Roediger & Butler, 2011). One such factor is the number of tests involved. Giving more than one test seems to increase the beneficial effect of retrieval practice, since the memory is enhanced and strengthened each time it is retrieved (Roediger & Butler, 2011). Also, the spacing of such repeated testing is of importance for the impact on learning (Halamish & Bjork, 2011; Pyc & Rawson, 2009; Roediger & Butler, 2011). Longer spacing between the tests, rather than conducting several tests during a short period of time, seems to increase its impact on learning, since difficult, but successful retrieval leads to better learning than easy successful retrieval (Karpicke & Roediger, 2007; Pyc & Rawson, 2009). What kind of memory test is used also matters, as a test involving production of the material to be learnt, such as a free recall test, seems to increase the efficacy of retrieval practice more than less cognitively demanding test types, such as recognition tests, multiple choice tests or cued recall (Halamish & Bjork, 2011; Gardiner, Craik & Bleasdale, 1973; Kang, McDermott & Roediger, 2007; Roediger & Karpicke, 2006a). Finally, if feedback is given after each test session along with an opportunity to restudy and correct what was not remembered on the previous test, this will benefit learning (Roediger & Butler, 2011). This benefit can also be discussed in terms of the indirect testing effect.

The use of repeated retrieval practice in classroom teaching is a rather uncommon procedure, partly due to the way tests are traditionally used in the classroom and partly due to the limited amount of time available for each subject and each course element. As one of the aims was to carry out the study in an authentic classroom environment, only one testing trial was included in the present thesis. A free recall test was used, since this is a more common test type than recognition tests in psychology teaching for older students, and because the testing effect tends to be stronger when free recall is used.

Why does retrieval practice affect learning?

Several different explanations of the testing effect have been suggested. One such explanation suggests that when a memory is strengthened, it is more easily remembered (Roediger & Butler, 2011; Rowland, 2014). Any form of studying strengthens the material learnt, but retrieval practice seems to strengthen the memory traces to a greater extent than for instance restudying (Kornell et al., 2011). Accordingly, knowledge that has been tested is easier to retrieve at a later occasion as it is still above the recall threshold (Roediger & Butler, 2011). As proposed by Bjork and Bjork (1992), in the active pro-
cess of retrieval, the elaboration of the memory trace is being increased, as are the retrieval routes to this trace, and learning in terms of future retainability of the material, is enhanced. In other words, when knowledge is retrieved, the ability to retrieve it again in the future improves (Karpicke, 2012; Karpicke et al., 2014).

Another explanation suggests that testing activates additional semantically related knowledge already stored in the memory (Carpenter, 2011). Since more semantically related knowledge is activated, more retrieval routes are created to the knowledge acquired, which facilitates retrieval at a later occasion (Carpenter, 2011). This account has mainly been suggested in experiments dealing with word pairs (Carpenter, 2011; Carpenter, 2009; Pyc & Rawson, 2010).

Other explanations to the testing effect have been proposed, such as testing providing re-exposure to successfully retrieved material and consequently providing the learner with more time to learn the material (Rowland, 2014; Thompson Wenger & Bartling, 1978; Tulving, 1967). However, more recent research has shown that the testing effect cannot be accounted for by the amount of time spent on the tested material, since the effect remains even when compared to the same amount of time invested in re-studying the material (Carpenter, 2009; Kang et al., 2007; Rowland, 2014).

Also, it has been suggested that the testing effect is strengthened if the final test is similar to the test type used in the learning phase, that is if the encoding and retrieval processes overlap (Kang et al., 2007). However, this hypothesis, often referred to as transfer appropriate processing (Blaxton, 1989), has received mixed support (Rowland, 2014; Duchastel & Nungester, 1982; Johnson & Mayer, 2009; Carpenter & Delosh, 2006; Kang et al., 2007). In addition, and as mentioned earlier, the magnitude of the testing effect is suggested to increase with the retrieval difficulty; the more effort needed in retrieving the material learnt, the more extensive is the reprocessing (Glover, 1989; Kang et al., 2007; Karpicke & Roediger, 2007; Roediger & Butler, 2011; Rowland, 2014).

Retrieval practice in subject-specific domains
As for multimedia learning, much of the research on retrieval practice in educational settings has been within the field of natural science (McDaniel, Agarwal, Huelser, McDermott & Roediger, 2011; Roediger & Karpicke, 2006a) and with less focus on material from other subject areas, such as the social sciences (but see Cranney, Ahn, McKinnin, Morris & Watts, 2009; Vojdanoska, Cranney & Newell, 2010; Carpenter, Pashler & Cepeda, 2009; Roediger et al., 2011). Research on the testing effect including a greater
variety of school subjects therefore ought to be prioritized (Roediger & Karpicke, 2006a), especially within the social sciences, which is the subject at focus in this work.
Learning styles

The idea that individuals’ learning styles are important to take into account when adapting classroom methods has reached wide popular acceptance within the educational field and among the general public (Riding & Cheema, 1991) and has over the last five decades generated a thriving industry with guide books, courses and assessment tools (Cassidy, 2004; Pashler et al., 2008). The learning styles hypothesis suggests that individuals acquire knowledge in different ways and that individuals differ in terms of what mode of instruction or study is most effective for them (Dunn, Beaudry & Klavas, 2002; Riding & Rayner, 2005). Accordingly, learning is thought to be less effective if instruction is not provided in accordance with a student’s learning style and conversely, individualizing instruction in accordance with the student’s learning style will optimize the individual’s learning, decrease failure generally and improve long-term results (Curry, 1990; Dunn et al., 2002; Pashler et al., 2008; Rayner, 2001; Rayner & Riding, 1997). For best learning, teaching methods should according to this idea be adapted to the individual students’ preferred mode of learning, since learning style in most studies, as in this thesis, focuses on the individual’s preference rather than ability (Childers, Houston & Heckler, 1985; Pashler et al., 2008). Riding and Cheema’s (1991) categorisation of learning styles in terms of a verbaliser – imager dimension suggests that some individuals may prefer, and should thus benefit more than others, from the use of a visual illustration, or from primarily verbal encoding. However, in a review of learning styles, Pashler and colleagues (2008) found only weak support for the learning styles hypothesis.

In Study II I investigate the conception of learning styles together with the robust notion of multimedia learning, focusing on whether individual differences in learning style preference should be applied in psychology teaching or whether multimedia learning applies equally to most students independently of learning style preference.
Defining learning style

Early research on learning styles used the term *cognitive style* rather than *learning style* and was by Allport (1937) defined as an individual’s typical or habitual mode of thinking, perceiving, remembering and solving problems. The learning styles term focuses on the application of cognitive style in a learning situation and came into use when the research focus was turned towards pedagogy and the classroom, matching course presentation and materials to the need of each individual learner (Kirby, 1979; Rayner & Riding, 1997; Cassidy, 2004).

Much research has been conducted in the area of learning styles during several decades (Cassidy, 2004). Nevertheless, due to varied aims of this research as well as a great diversity of isolated domains, contexts and disciplines in which this research has been conducted, the learning style topic has become rather disparate, fragmented and elusive (Riding, 1997; Cassidy, 2004; Riding & Cheema, 1991). As a result, a large variety of concepts, definitions, style labels and assessment instruments have been developed in the learning style field (De Bello, 1990; Riding, 1997; Riding & Cheema, 1991; Swanson, 1995). Claxton and Murell (1987) concluded that until further research has provided a more refined theoretical base, a final agreement on any definition will probably not be reached. In the present work I define learning style as an individual’s way of perceiving, processing and recalling information, which is in line with Scarpaci and Fradd’s (1985) as well as De Bello’s (1990) definitions. As in most learning styles studies (Pashler et al., 2008; Childers et al., 1985), the term learning styles focuses on the individual’s preference of mode rather than ability. Also, learning style needs to be distinguished from learning strategy, as style can be considered an individual, relatively stable preference, whereas strategy can be considered ways to deal with learning tasks, which may vary from time to time (Riding & Cheema, 1991).

The onion model

The characteristics considered relevant in learners and instructional settings vary a lot between different learning style models: some are multidimensional, including cognitive, affective as well as physiological characteristics, whereas others focus on single cognitive variables (Cassidy, 2004; Curry, 1990; De Bello, 1990; Pashler et al., 2008). In order to organize the many different learning style theories, their models, schemes and assessment instruments, Curry (1983) developed a layer-like model in terms of an onion metaphor. The different layers of the onion are comparable to the different levels of an individual’s learning style. The centre of the onion represents style in terms of *basic personality traits*. The next layer deals with infor-
motion processing, which is the individual’s preferred approach to assimilate knowledge. The third layer addresses a student’s social interaction in the classroom, followed by the final, outermost, layer concerned with instructional preference. The innermost levels are considered the most stable and are less likely to change, whereas the preferences related to the outermost levels are considered less stable and more open to change (Curry, 1983; Swanson, 1995). Study II focuses mainly on instructional preference aspects of learning style, as in the outermost layer.

The verbaliser – visualiser dimension

Study II is based on Riding and Cheema’s (1991) suggested categorisation of learning styles in terms of a verbaliser – imager dimension, addressing the degree to which an individual tends to process knowledge acquired as words or images. The notion of people having a tendency to process a material to be learnt mainly verbally or visually is not a new idea (e.g. Galton, 1883; James, 1890; Bartlett, 1932; Riding, 1997). Paivio (1986) continued this work in developing the dual coding theory, suggesting that information is processed in two different channels, a verbal and a visual (Paivio, 1986; Mayer, 2009). In line with Riding and Buckle’s (1990) description, ‘imager’ is in this work considered a synonym to what Paivio (1971), Richardson (1977) and other researchers labelled ‘visualiser’.

Several studies on learning styles have focused on the verbaliser – visualiser dimension (e.g. Cassidy, 2004; Riding & Cheema, 1991; Alesandrini, 1981; Massa & Mayer, 2006; Constantinidou & Baker, 2002; Riding, 1997). However, the results from studies looking into this dimension of learning styles are contradictory (Cronbach, 2002). Some studies suggest that visualisers learn better from visual presentations and that verbalisers learn better from verbal presentation (e.g. Riding & Ashmore; 1980; Riding & Douglas, 1993; Riding, Buckle, Thompson & Hagger, 1989; Richardson, 1977), whereas other studies find no support for the learning styles hypothesis in terms of the verbaliser - visualiser dimension (Massa & Mayer, 2006; Constantiniou & Baker, 2002; Heckler, Childers & Houston, 1993). Study II investigates the verbaliser – visualiser dimension of learning styles further, and importantly, relates it to the multimedia effect.

Learning styles assessment

In order to help educators to identify the students’ individual learning styles, an assessment is conducted, often focusing on what presentational mode a
person prefers and what kind of mental activity one finds most engaging (Pashler et al., 2008; Riding & Cheema, 1991; Riding & Rayner, 2005). There is a large amount of different learning style assessment tools at hand and they are very diverse (Pashler et al., 2008).

The Style of Processing questionnaire
In Study II, the Swedish version of the Style of Processing questionnaire (SOP) is used to assess learning style (Childers et al., 1985; Kalén, Maynard, Svensson & Östergren, 2002). The questionnaire focuses on the verbaliser - visualiser dimension of learning style and aims to define a person’s “preference and propensity to engage in a verbal and/or visual modality of processing” (Childers et al., 1985, p 130), including both receiving instruction and processing information. The results from the SOP questionnaire place students in one of three learning style groups: visual, mixed or verbal, where visual and verbal students have clear preferences for one or the other presentation format, whereas students with a mixed learning style do not (Heckler et al., 1993; Ramsey & Deeter-Schmelz, 2008; Riding, et al., 1989).

The SOP questionnaire is based on Richardsson’s (1977) Verbaliser-Visualiser Questionnaire (VVQ), which in turn stems from Paivio’s (1971) 86-item Ways of Thinking-questionnaire, initially developed utilising his dual-coding theory (Ramsey & Deeter-Schmelz, 2008). The SOP questionnaire is considered a more rigorous instrument than the VVQ, has higher external validity and internal consistency as well as a good construct validity and test-retest reliability (Childers et al., 1985; Heckler et al., 1993; Ong & Milech, 2004; Ramsey & Deeter-schmelz, 2008). It consists of 22 items, answered along a four-point Likert scale ranging from “always true” to “always false”.

In the present work students were presented with a lecture either only verbally or verbally together with the aid of a visual illustration (i.e., visuoverbal presentation). The verbal learning style was thus matched with a verbal presentation format, and the visual and mixed learning styles were matched with a visuoverbal presentation format. I did not include a purely visual presentation format, since the study was conducted in an applied classroom setting, where purely visual instruction would not be contextually realistic.

Critique of the research on learning styles
It is uncontroversial that individuals will differ in some respects in terms of what instructional method is optimal for them, due to for instance educa-
tional background, prior knowledge and cultural assumptions (McNamara, Kintsch, Butler-Songer, & Kintsch, 1996; Pashler et al., 2008). Also, individuals have different preferences when it comes to acquiring new knowledge, and several studies have shown a significant correlation between a student’s preference and his/her choice of instructional mode in the learning situation (Massa & Mayer, 2006; Childers et al., 1985; Ramsey & Deeter-Schmelz, 2008; Pashler et al., 2008). Nevertheless, the idea that instructional preference exists and differs between individuals does not in itself say anything about what these preferences might imply, that is if the student actually learns better through his/her preference and whether or not it is sensible for educators to take individual preference into account in their teaching (Pashler et al., 2008). Also, research on memory and metacognition shows that our intuitive beliefs about how we best learn are often wrong (Schmidt & Bjork, 1992; Schwartz & Efklides, 2012; Pashler et al., 2008).

Many researchers have raised criticisms concerning the learning styles research on aspects such as confusion in definitions, an unclear conceptual framework, low reliability and validity of measurements, an unclear identification of relevant characteristics in learners and in instructional settings, and methodologically related problems (Curry, 1990; Cassidy, 2004; Pashler et al., 2008). Further, both Kavale and Forness (1987) and Pashler and colleagues (2008) concluded that it is hard to find learning styles studies that do not have methodological problems and that the studies without such problems seem to contradict the learning styles hypothesis (e.g., Constantinidou & Baker, 2002; Kollöffel, 2012; Massa & Mayer, 2006). Obviously these and other similar studies do not imply a conclusive refutation of the learning styles hypothesis, however, more appropriately carried out research providing stronger evidence for the hypothesis is needed before learning styles are applied in the general educational practice (Cassidy, 2004; Curry, 1990; Pashler et al., 2008; Willingham, 2005). In this thesis, I aim to investigate the notion of learning styles further in terms of visualisers and verbalisers.

Pashler and colleagues (2008) suggested that convincing support for the learning styles hypothesis would demand a crossover interaction. This means that the learning styles hypothesis will be supported if, and only if, the learning method that optimises learning for students with one learning style is different from the method optimising learning for students with another learning style. In terms of Study II in the present work, this would mean that visualisers should perform better in a visual condition than verbalisers and vice versa.
Overview of Studies

General Aims

The overall aim of this thesis was to investigate the possible impact of visual illustrations and retrieval practice on learning psychology, in order to draw conclusions about possible implications for upper secondary psychology teaching. Study I focuses on this combination of the learning strategies. Study II investigates possible individual aspects of the impact of visual illustrations on learning psychology in terms of verbal versus visual learning style. Through looking further into the use of visual illustrations and retrieval practice in upper secondary psychology teaching, and in relating those results to the notion of individual differences in terms of learning styles, I hope to extend the understanding of the impact of those aspects in psychology teaching.

Method

Participants

One data collection was conducted for the two studies presented in this thesis and different parts of the data set is focused upon and presented in the two separate studies. A total of 215 upper secondary students from three different schools in Stockholm, Sweden, participated in the study. The mean age of the participants was 17.3 years and there was an almost equal number of men and women (110 men and 105 women). Participants were tested in 12 already existing classes, which did not differ in terms of working memory capacity, tolerance for mental effort or of self-rated previous knowledge about the content covered. As all participants were in their second year, no one had yet taken the psychology course. All three schools included in the study had a rather large catchment area and students with mixed socioeconomic backgrounds. One of the schools had slightly higher grades as shown in the national statistics, whereas the other two schools were similar in this aspect.
Materials

The to-be-learned material consisted of the Atkinson-Shiffrin memory model (Atkinson & Shiffrin, 1968), presented orally or both orally and visually. The presentation as well as the visual illustration was derived from two high school textbooks in psychology (Fält, 2003; Smith, 1999) and outlined the flow from sensory memory, to short-term memory and to long-term memory (Figure 2).

A final learning test, similar to that presented by Mayer and Moreno (1998), consisting of an open-ended recall question and five transfer questions, was used. The recall question asked the students to write down everything they could remember from the presentation, whereas the transfer questions examined the students’ understanding of the content presented.

The Swedish version of the Style of Processing questionnaire (SOP; Childers et al., 1985; Kalén et al., 2002), a 22-item questionnaire assessing verbal - visual cognitive style, measured the students’ preferred way of acquiring and processing new knowledge.

![Figure 2. Visual illustration of the Atkinson-Shiffrin memory model, drawn for one half of the classes.](image)

Procedure

A verbal presentation of the structure of the memory was being held in the classroom, with a visual illustration, including all different steps in the orally presented process, drawn simultaneously on the white board for one half of the classes. All students were then given ten minutes to work with the material presented. In Study I participants either restudied the written manuscript of the verbal presentation (restudy group) or were asked to write down everything they could remember from the presentation (retrieval practice group). In Study II all students restudied the written manuscript. Finally, the
students were asked to answer the recall question (8 minutes) and the five transfer questions (3 minutes each), as well as fill in the SOP questionnaire. In Study I participants were tested at three different occasions; immediately and with retention intervals of one and ten weeks. In Study II only immediate testing was included. The assignment to the different learning conditions in terms of both presentation format (verbal vs. visuoverbal, as used in Study I and II) and study strategy (retrieval practice vs. restudy, as used in Study I) was random. A third study strategy, discussion in small groups, was included in the data collection, but was because of the limited scope of this thesis not covered in any of the two studies included. The data collection was carried out during the first half of the spring term and the to-be-learnt material was not further worked on in school between the sessions.

Scoring and Analyses

For the recall question, one point was given for each of the main ideas presented in the verbal presentation. Similarly, one point was given for each acceptable answer on the transfer questions. Scores were not given for vague answers, but for answers worded differently from the verbal presentation. The recall scores were summed and calculated into proportions, as were the transfer scores. When analysing scores from recall and transfer tests combined (Study II), a mean proportion of the two test scores was calculated. The data were analysed with analyses of variance (ANOVA) and t-tests. For effect sizes, Cohen’s $d$ was calculated.

Ethical aspects

The research was conducted in accord with APA standards as well as the ethical guidelines from the Swedish Research Council. All students were informed about the purpose of the research as well as the procedures involved. Also, all students were asked to give their consent to participating and were informed that they had the rights to decline to participate and to withdraw their participation at any time. One student chose not to participate. Also, all data has been handled with confidentiality.
Study 1


Aim

The aim of Study I was to increase the understanding of how students learn a verbal description of an abstract psychological phenomenon, with or without the help of visual illustration and/or retrieval practice. More specifically I was interested in investigating (i) to what extent multimedia learning affects recall and transfer in learning psychology, (ii) to what extent retrieval practice (vs. restudy) influences retention and transfer in learning psychology, and (iii) on which strategy should one put the efforts or should they be combined for best learning?

Background

Much teaching and learning research has focused on students’ cognitive activities when studying (Dunlosky et al., 2013). In this study I compared two robust learning strategies in an applied setting: multimedia learning, suggesting that people learn better with words and pictures combined than from words alone, and retrieval practice, referring to memory testing as a learning strategy that often leads to better long-term recall than, for example, restudying (see Mayer, 2011; Roediger & Karpicke, 2006a, for reviews). Both these methods have, when investigated in isolation from each other, proven rather robust. However, for teachers and students to be able to make informed decisions about how to best improve learning, it is important to compare learning strategies that are known to be effective (see Kornell et al., 2012, for a similar argument). For example, most studies on retrieval practice have compared testing to exact repetition, a learning strategy known to be ineffective, however it has yet not been compared to many common and effective learning techniques (Kornell et al., 2012). It is therefore worthwhile to study the two effects in combination, and in particular in a classroom setting. Roediger (2013) emphasised the combinations of techniques as a consideration for future studies. Retrieval practice has in different studies been combined with multimedia material (Johnson & Mayer, 2009), but I know of no study that has investigated the combined effect of multimedia learning and retrieval practice.

A majority of previous multimedia learning and retrieval practice research has been conducted in laboratories or with computers as the teaching tool, focusing on material from the natural sciences or mathematics (Kartal, 2010;
In the present study, I used an authentic classroom situation, and material from the social sciences.

**Method**

A total of 133 students, all belonging to the restudy or retrieval practice groups, participated in the study. Students assigned to the discussion group were accordingly excluded, as this study strategy was not part of the study. After the oral presentation, for one half of the classes combined with a simultaneously drawn visual illustration, the participants were asked to work with the material presented according to their randomly assigned study strategy. Finally, the students were asked to conduct a learning test, which was completed again one and ten weeks later (see Figure 3 for a specific description of the design).

![Figure 3. Design of Study I.](image)

A dropout analysis was conducted, as there was a relatively large dropout from the immediate testing occasion until the final test ten weeks later. However, when comparing dropouts with student that remained throughout the study, no differences were found. The dropout rate is therefore unlikely to have affected neither the results nor the conclusions drawn in the present study.

**Results**

A significant main effect of presentation format was found $F(1, 84) = 12.47, MSE = 1.46 p = .001$ (visuo-verbal: $M = .52, s = .14$; verbal: $M = .41, s = .14, d = 0.79$). The combined presentation of visual and verbal information resulted in better learning compared to only verbal presentation (see Figure 4). Accordingly, the multimedia effect was replicated and was found stable over time and in terms of both recall ($d = 0.73$) and transfer ($d = 0.64$).
A marginally significant testing effect was found in terms of a lower forgetting rate over time for the retrieval practice group compared to the restudy group (see Figure 5). This can be seen in the significant study strategy by retention interval interaction, $F(2, 84) = 3.04, MSE = 0.03, p = .051$. By excluding the third retention interval, and thus increase the number of participants and the statistical power, the study strategy by retention interval interaction was clearly significant, $F(1, 112) = 6.82, MSE = 0.08, p = .012$, underscoring the finding that testing led to less forgetting than study-only. Although I did see a positive benefit of retrieval practice in terms of less forgetting (i.e., the interaction effect), retrieval practice actually did not lead to better memory in the long term.

Figure 4. Mean proportion correct answers across the three retention intervals for the verbal presentation only and visuoverbal presentation groups respectively. Error bars represent the standard errors.

![Figure 4](image)

Figure 5. Mean proportion correct answers across the three retention intervals for the restudy group and the retrieval practice group, respectively. Error bars represent the standard errors.

![Figure 5](image)
There was no statistically significant interaction effect between study strategy and presentation format \((F<1)\), nor an interaction between study strategy, presentation format and retention interval \((F<1)\). This means that retrieval practice did not reliably improve the participants’ memory performance beyond the beneficial effect of visuoverbal learning. Hence, at least in the present study, presentation format proved to be a more important factor for learning (i.e., higher test scores) than study strategy.

Conclusions
Consistent with previous multimedia learning research (Mayer, 2011), this study suggests that a visuoverbal presentation results in better learning than verbal presentation only in terms of both recall and transfer. A testing effect was found in terms of a lower forgetting rate over time for the retrieval practice group compared to the restudy group (i.e., the interaction effect), but retrieval practice did not lead to better memory in the long term. The results show that the multimedia effect holds in an authentic classroom setting, over a longer timespan, and with material from the social sciences.

A testing effect was found in terms of less forgetting over time for the retrieval practice group. However, in contrast to earlier research (Carpenter, 2012), I did not find a testing effect for the transfer test only. One possible reason for this, which may also explain the non-existing testing effect in terms of better memory for the retrieval practice group on delayed testing, could be the lack of feedback, which according to several studies seems to strengthen the testing effect (Pashler et al., 2005). In the view of the results showing a robust multimedia effect but only a rather modest testing effect, it may not be surprising that the two effects did not enhance each other. In this study, the use of a visual illustration seemed to be an even more important factor for learning than was retrieval practice.

Traditional school instruction tends to favour verbal (auditive or written) rather than visual modes of presentation (Danielsson & Selander, 2014; Mayer, 2011, Tønnessen, 2009). Likewise, tests have tended to mainly be used as tools of summative assessment and evaluation of learning (Dunlosky et al., 2013). The findings of my and similar studies show that visual representations, as well as tests, can be used in order to improve the learning process (Mayer, 2011; Dunlosky et al., 2013). It seems worthwhile to put effort into creating visual representations in order for students to even better acquire and process new knowledge. This should be the case in everyday classroom teaching as well as in textbooks used in schools. Our research extends earlier research in that it combines two robust learning strategies and shows that in the present dataset multimedia learning clearly fairs better than retrieval practice.
Study 2


Aim

In Study II I investigated the learning styles hypothesis in terms of the verbaliser-visualiser dimension, and the multimedia instruction hypothesis in psychology teaching. A key issue is whether teachers in their efforts to further improve student learning should adapt their teaching according to students’ preferred learning style (verbaliser – visualiser), or whether they should instead focus their efforts on a strategy that work well for most students, independent of preference (multimedia learning).

Background

The idea that individuals’ learning styles are important to take into account when adapting classroom methods has reached wide popular acceptance within the educational field and among the general public (Riding & Cheema, 1991). The learning styles hypothesis suggests that people acquire knowledge in different ways and that individuals differ in terms of what mode of instruction or study is most effective for them (Dunn et al., 2002; Riding & Rayner, 2005;). Some individuals may accordingly prefer, and should thus benefit more than others, from the use of a visual illustration, or from primarily verbal encoding. The present study is based on Riding and Cheema’s (1991) suggested categorisation of learning styles in terms of a verbaliser – imager dimension, addressing the degree to which an individual tends to process a material to be learnt as words or images. This categorisation stems from dual coding theory, suggesting two separate channels for information processing, a verbal and a visual (Mayer, 2009; Paivio, 1986). However, criticism has been raised concerning the lack of evidence for the learning styles hypothesis (Pashler et al., 2008) and the results from studies considering the verbaliser – imager dimension of learning styles are inconsistent and the issue needs further attention (Riding & Douglas, 1993; Smith and Woody, 2000; Massa and Mayer, 2006; Constantinidou & Baker, 2002). In the present work I aim to further investigate this matter.

Another teaching method, not based on individual differences in students’ preferences, is multimedia learning, which has been proven to be a robust learning strategy (Jägerskog, Jönsson, Selander, & Jonsson, 2015; Mayer, 2009; Paivio, 1986). The core assumption of the multimedia instruction hypothesis is that individuals learn better from words and pictures combined
than from words alone (Mayer, 2010; Paivio, 1986), indicating that this applies to people in general. However, studies focusing on the effects of different presentation formats in teaching often fail to take into account the role of individual differences (Kollöffel, 2012). Study II aims at doing this.

Method

72 students (37 women and 35 men) were included in the study. As focus was on the effects of learning style and multimedia learning as unconfounded by the effects of discussion and testing, only the restudy condition was included. Also, as focus was not on learning over time, but rather on the general relation between presentation format and preferred learning style, no retention intervals were included in this study. Accordingly, no dropout analysis was needed. The students were given the oral presentation of the to-be-learned material, verbally for one half of the classes and visuoverbally for the other half, followed by the students conducting the learning test and completing the Swedish version of the Style of Processing questionnaire (SOP; Childers et al., 1985; Kalén et al., 2002).

Results

Three interesting results emerged from the ANOVA conducted. First, the multimedia instruction hypothesis was supported in a significant main effect of presentation format $F(1, 71) = 27.37, MSE = .55, p < .001$. As shown in Figure 6, students who received visuoverbal instruction scored significantly higher on the learning test compared to students who only received a verbal presentation ($d = 1.12$). In terms of effect sizes, and as shown in Figure 8, visuoverbal learning was better than verbal learning independently of learning style (visual, $d = 2.63$; mixed, $d = 0.99$; verbal, $d = 0.63$).
Second, a significant main effect of learning style was found $F(2,71) = 5.79, \text{MSE} = .12, p = .005$. As shown in Figure 7, students with a visual ($p = .01$) or a mixed ($p = .01$) learning style performed generally better on the learning test compared to students with a verbal learning style. Note that this main effect does not refer the learning styles hypothesis, but shows that those who have a mixed or visual learning style preference perform better on the learning test independent of presentation format.

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**Figure 6.** Mean proportion correct answers for the verbal and visuo- verbal presentation formats respectively. Error bars represent the standard errors.

**Figure 7.** Mean proportion correct answers for all participants across the different learning style groups. Error bars represent the standard errors.
Third, I inspected the results for possible support for the learning styles hypothesis, that is, whether there was a reliable learning style by presentation format interaction. The data analysis showed a marginally significant interaction between learning style and presentation format, $F(2, 71) = 3.12$, $MSE = .06$, $p = .051$. As shown in Figure 8, this interaction was driven by participants with a visual learning style benefitting more from a visuoverbal presentation format than participants with a mixed or verbal learning style.

![Figure 8](image.png)

**Figure 8.** Mean proportion correct answers across the different learning style groups for the verbal and visuoverbal presentation formats respectively. Error bars represent the standard errors.

**Conclusions**

Consistent with much of the previous research (e.g., Constantinidou & Baker, 2002; Mayer, 2010; Mayer & Moreno, 1998; Moreno, Mayer, Spires & Lester, 2001; Paivio, 1986) a visuoverbal presentation resulted in better learning than a verbal presentation only. Notably, in terms of effect sizes this was the case independently of preferred learning style, which renders strong support for the multimedia instruction hypothesis. I found no support for the learning styles hypothesis in terms of the verbaliser – visualiser dimension, as there was no crossover interaction between learning style (visual or mixed vs. verbal) and presentation format (see Pashler et al., 2008). However, similar to Heckler and colleagues (1993), I found that visualisers benefited more from the switch from verbal to visuoverbal presentation than verbalisers. Although a partial result in line with the idea that learning styles may matter...
(i.e., only for the visualisers), the absence of the required crossover interaction makes this finding less convincing.

Based on the results from this study it is possible conclude that classroom teaching in general should not be adjusted according to individual students’ preferred learning style in order for each student to best learn. However, the results suggest two other possible implications for classroom teaching. First, since the use of visual illustrations seems to have a beneficial effect on learning for most students independent of their preferred learning style, the present data indicates that a visual or visuoverbal mode of instruction ought to be used in psychology classroom teaching for the age group tested. Second, students with a visual or mixed learning style outperformed students with a verbal learning style on the learning test in general. Given that learning style is considered a preference rather than an ability (e.g., Childers, 1985; Pashler et al., 2008) a question arises if students can be guided towards a visual preference and thereby increase their learning. If this is the case, classroom teaching should encourage and create possibilities for students to develop a preference for visual or multimodal aspects of learning.

Because this study only investigates psychology learning in emerging adulthood future studies should focus on for instance younger participants, different subject content and children with diagnosed learning difficulties in order to address the full potential of these findings for teaching. I concur with some previous researchers in that more research is needed about learning styles before implementation in educational practice (Cassidy, 2004; Curry, 1990; Pashler et al., 2008). In the meantime, this study suggests that the use of visual illustrations ought to be encouraged in psychology teaching for all upper secondary students, independently of preferred learning style.
General Discussion

The general aim of this thesis was to contribute to the understanding of the possible impact of visual illustrations and retrieval practice in learning psychology, in order to draw conclusions about possible implications for upper secondary psychology teaching. Both multimedia learning and retrieval practice have been found robust learning strategies in earlier research (Roediger & Karpicke, 2006a; Mayer, 2011). However, this thesis extends previous research in the area through combining the two learning strategies in the same study, investigating how well they stand in relation to each other and whether or not the combination of the two further enhances learning.

Given the results from Study I, which showed strong support for the multimedia instruction hypothesis, Study II investigated the beneficial effects of the use of visual illustrations in more detail. The aim was to look into individual differences in terms of preferred learning style, as studies focusing on the effects of different presentation formats in teaching often fail to take individual differences into account (Kollöffel, 2012). Previous learning styles research has been contradictory and many studies have methodological problems (Kavale & Forness, 1987; Pashler et al., 2008). The present thesis adds to existing research by taking aspects of learning style into consideration when investigating the role of multimedia learning, by following methodological criteria requested for learning styles studies by for instance Pashler and colleagues (Pashler et al., 2008) and by adding some more insight to the still rather unclear usability of the learning styles concept.

An ambition with this thesis was also to carry out the study in an authentic educational environment, with a material based on content from the social sciences and with a longer retention interval, as much previous research on multimedia learning and retrieval practice has been conducted in laboratory settings and/or with the computer as the learning tool, based on materials from the natural sciences and mathematics and with shorter retention intervals. The studies in this thesis contribute to earlier research in the area by using educationally relevant material from a psychology course, conducting the research in a classroom setting and investigating learning over a very long retention interval (ten weeks).

In the following sections I will discuss the results under the themes visual illustrations and retrieval practice. I will also discuss possible practical implications and methodological challenges. Finally I will make some conclud-
ing remarks concerning suggestions for future research and challenges ahead.

Visual illustrations

I found strong support for the use of visual illustrations in teaching in order to improve learning. Also, the multimedia effect seems to hold in an authentic classroom setting and over a longer time span, aspects not vastly investigated, but highly relevant for educational practice.

Further, our results contradict the findings presented by Westelinck and colleagues (2005). They conclude that the multimedia instruction hypothesis is not generally applicable in the social sciences as it is in the natural sciences, since visual illustrations in the latter area, as opposed to the former, are built on consensual iconic sign systems already acquired by the students. The present results suggest that the multimedia effect can hold also within the social sciences, in this case psychology, independently of a consensual iconic sign system already acquired by the students. It is possible that creating good visual illustrations is an even larger challenge in the social sciences, based on Westelinck’s (2005) argumentation. Nevertheless, the robustness of multimedia learning as shown in my studies, seems to overcome possible iconic sign related difficulties of a certain domain.

Visual illustrations and learning styles

We know from earlier research that individual differences have an impact on the effectiveness of visual illustrations as an aid in teaching (Cook, Carter & Wiebe, 2008; Kalyuga et al., 1998; Mayer, 1997; Mayer & Sims, 1994). We also know that learning styles have become a popular phenomenon often used and referred to in different educational settings (Cassidy, 2004; Pashler et al., 2008; Riding & Cheema, 1991). It is therefore interesting to relate multimedia learning to learning styles in terms of visualisers and verbalisers.

Study II showed that the positive effects of learning with the aid of a visual illustration holds independently of preferred learning style. Learning was further enhanced for verbalisers as well as visualisers and students with a mixed learning style when given a visuoverbal presentation compared to a verbal. This renders strong support for the multimedia instruction hypothesis in terms of its generalizability and raises questions about the applicability of learning styles.

As suggested by Pashler and colleagues (2008), a convincing support for the learning styles hypothesis would require a crossover interaction, where visualisers perform better than the verbalisers when a visual illustration is
used and vice versa. This was not the case in my study, since students with a verbal learning style did not outperform students with a visual learning style when the presentation was purely verbal. Accordingly support for the learning styles hypothesis in terms of the verbaliser – visualiser dimension was not provided. However, an interaction was found between learning style and presentation format in that visualisers benefited more from a visuoverbal presentation than verbalisers and students with a mixed learning style, results similar to those presented by Heckler and colleagues (1993). This may be seen as giving partial support for the learning styles hypothesis in terms of the visual dimension. However, the p-value for the interaction is at the limits of statistical significance, allowing no solid conclusions.

Most interestingly, students with a visual or mixed learning style outperformed students with a verbal learning style on the learning test in general, results similar to those of Massa and Mayer (2006). The verbal presentation format, as well as the verbal learning style, seems to result in the lowest learning outcome. However, these results are contradictive to some other studies where verbalisers had a stronger retention than visualisers (Childers et al., 1985; Richardson, 1978) and more research is therefore needed to clarify this issue.

**Practical implications**

Traditional school instruction tends to favour verbal (auditive or written) rather than visual modes of presentation (Danielsson & Selander, 2014; Mayer, 2011, Tønnessen, 2009) and the use of visual tools could well be increased in education (Rundgren and Tibell; 2009). The findings of my studies suggest that visual illustrations can be used in order to improve learning in psychology. Developing good visual illustrations is not an easy task and many aspects need to be taken into consideration, as suggested by for instance Mayer (2011) and Levin and Mayer (1993). However, it seems worthwhile to put effort into creating such illustrations in order for students to even better acquire and process new knowledge in psychology. This should be the case in everyday classroom teaching as well as in textbooks and for all students independently of learning style. As the use of visual illustrations seems to be more developed in the natural than in the social sciences, even more effort may be needed in the latter area. Teachers, students as well as people designing course books ought to be aware of the importance of visual illustrations in teaching and learning psychology and actively use such illustrations when possible.

As noted earlier, visual literacy can be defined in terms of the ability to read, interpret and understand information presented visually (Wileman, as cited in Stokes, 2002). Knowing that an improvement in learners’ visual literacy can increase the effect of visual illustrations in teaching (Peeck,
1993) and that visual literacy is considered a skill that can be developed through practice (Felten, 2008; Stokes, 2002), the use of visual illustrations in teaching becomes even more interesting and important as a way of helping students to improve learning. Especially so, since visual literacy is not a competence automatically mastered through the rapid growth of visual technologies in our society, as we might sometimes believe (Pauwels, 2006). In order to encourage and provide conditions for developing visual literacy among students, the use of visual illustrations in teaching should not be limited to certain subjects or age groups, but ought to be encouraged in teaching in many different subjects and for older as well as younger students. Traditionally, visual illustrations are used more frequently in younger classes and tend to become less frequent in the older stages of school. The results from the two studies included in this thesis suggest that psychology teachers should use visual illustrations also for older students. In doing so students may be helped to further develop their visual literacy.

Given that students with a visual or mixed learning style outperformed students with a verbal learning style on the learning test in general and given that learning style is considered a preference rather than an ability (e.g., Childers, 1985; Pashler et al., 2008) a question arises if students can be guided towards a visual preference and thereby increase their learning. Childers and colleagues (1985) suggested that the style of processing includes both propensity and preference for verbal and/or visual modes of processing, including attentional as well as elaborational stages of information processing. This could imply that students have the possibility of making a shift towards more visual or multimodal preferences in learning. Similarly, Curry (1983) suggested that the preferences related to the outermost levels of the onion model (Curry, 1983), such as instructional preference, are considered less stable and more open to change (Curry, 1983; Swanson, 1995). In addition, some researchers have suggested that a person with a visual learning style may be prone to use mental imagery more than individuals with a verbal learning style and therefore to a greater extent use the working memory to form visual mental representations of cues also when presented with verbal information only (Heckler et al., 1993; Riding et al., 1989). This could be termed as an “internal multimedia effect” and an explanation to why students with a visual or mixed learning style seem to learn more than verbal processors from the same material. Some researchers in the area of mental imagery suggest that improvement of imagery strength may be possible through practice (Rademaker & Pearson, 2012), which could be an implication of the possibility of change in a person’s learning style towards a more visual or multimodal preference. If this is the case, classroom teaching should encourage and provide possibilities for students to develop the ability to create visual mental representations. In line with this, Price (2004, p. 686) suggested that “visual representations can facilitate the development of students’ own
mental models, enabling them to visualise abstract concepts”. Creating and using illustrations in teaching that visualise abstract concepts may be one way of guiding students towards a more visual or multimodal preference in learning. Also, an active use of visual illustrations in psychology teaching may help students develop the ability to create such visual illustrations themselves - internally or externally - and thereby facilitate further learning.

Research on memory and metacognition shows that our intuitive beliefs about how we best learn are often wrong (Pashler et al., 2008; Schmidt & Bjork, 1992; Schwartz & Efklides, 2012; Todorov, Kornell, Larsson & Jönsson, 2013) and learning style preference does not seem to be an exception. Learning style tests may therefore not be helpful in defining how we best learn. Rather than being a tool for teachers to adapt their teaching according to each student’s individual learning style it is possible that a learning styles test instead could be used in order to identify students who need to develop their study strategies towards a more visual preference. However, since results from different studies point in different directions concerning this issue, more research is needed (Massa & Mayer, 2006).

All students are individuals and have individual needs dependent on for instance age and past experience. Individual differences are naturally important to consider in all teaching and learning situations. However, my results suggest that the best way to meet individual differences is not through adapting the idea of learning styles in everyday teaching. Assuming that students have a certain learning style may risk that focus is given to an individual’s fairly fixed learning style rather than the possibility to develop flexibility in modes of processing (Curry, 1990; Kirby, Moore & Schofield, 1988). Possibly the idea behind learning styles might be more relevant for subjects and subject content than for individuals, in that different subjects, tasks and subject content need different instructional modes (Constantinidou & Baker, 2002; Kollöffel, 2012; Pashler et al., 2008; Price, 2004; Riding, Grimley, Dahraei & Banner, 2003; Willingham, 2006). Teaching geometry may for instance require more visual and spatial aspects of instruction, whereas the optimal instructional method when teaching about writing may be more verbal (Pashler et al., 2008). The rather unstable outermost layer in Curry’s onion model may accordingly be dependent on variations in situations and subject content. Identifying optimal instructional methods for each subject matter obviously requires a growing body of subject-specific research (Pashler et al., 2008). In line with results from many other studies (see Pashler et al., 2008 for a review), my results suggest that students’ preferred individual learning styles should not be a focal aspect for teachers when planning their teaching.
Retrieval practice

A weak testing effect was found in Study I in terms of the retrieval practice group forgetting less over time than the restudy group. However, the retrieval practice group never outperformed the restudy group on the delayed testing. Also, the testing effect was found for recall but not for the transfer test only, in contrast to some earlier research (Carpenter, 2012; Karpicke, 2012; Butler, 2010; Rohrer et al., 2010). There are several reasons that possibly can explain why the benefits of retrieval practice were not as robust as shown in several other studies (Leeming, 2002; McDaniel et al., 2007; Vojdanoska et al., 2010; Cranney et al., 2009; Rohrer et al., 2010; Carpenter et al., 2009; McDaniel et al., 2011). First, feedback seems to strengthen the testing effect, but was not used in our study (Pashler, Cepeda, Wixted, & Rohrer, 2005; Butler & Roediger, 2007). Second, only one practice test session was used, since the study was carried out in an authentic school context where the still quite uncommon procedure of repeated retrieval in itself could have confounded the results. Roediger and Butler (2011) suggested that memory performance generally increases after repeated test sessions. Third, in an authentic classroom context there are several factors not controlled for, that could affect the results and decrease the expected testing effect (Roediger & Karpicke, 2006a). Fourth, the fact that all students took the same tests three times over the ten week period should decrease the magnitude of the testing effect, since the conditions became more and more similar over time. Except for the use of a cognitively more demanding test type (i.e. a free recall test), factors that seem to increase the impact of retrieval practice on learning were not applied in the learning session of this study, since they did not naturally fit in to the authentically carried out lecture. Nevertheless, and despite the aspects mentioned above, a significant testing effect, in terms of the retrieval practice group forgetting less than the restudy group, was found.

Interestingly, the decrease in recall rate but not in transfer rate over the ten week retention interval suggests that the students forgot facts and details over time, but that the understanding of the content still remained after the ten weeks. A possible explanation could be that some of the fact details had been encoded more shallowly and were thus forgotten over time, whereas the understanding of the content had been processed more deeply, creating more durable memory traces (Craik & Lockhart, 1972). Also, it is possible that the understanding of the content remains, even though not all facts are remembered.

Retrieval practice did not reliably improve the participants’ learning beyond the beneficial effect of using a visual illustration. Hence, the two learning strategies did not enhance each other. This is not surprising in the light of results showing a robust multimedia effect but only a very modest testing
Multimedia learning emphasises three processes activated in learning: selecting, organizing and integrating. In retrieval practice three partly different cognitive processes are emphasized: encoding, storing and retrieving. Those different processes partly overlap, however there seems to be a focus on the encoding processes in multimedia learning (Mayer, 2009) and on the retrieval processes in retrieval practice (Karpicke, 2012). Since the two strategies partly activate different aspects of the learning process, it is reasonable to believe that the two strategies could uniquely contribute to learning and therefore be additive. Possibly, synergistic effects of the two learning strategies might have been found with a more convincing testing effect and I would not be surprised if future studies, addressing some of the potential limitations of the present study, will find additive effects of the two learning strategies. Nevertheless, the present study gives reason to conclude that multimedia learning is an even more robust learning strategy than retrieval practice.

Practical implications
Tests have in education tended to mainly be used as tools of summative assessment and evaluation of learning (Dunlosky et al., 2013; Vojdanoska, 2010). Although I did not find a strong testing effect, the findings of my and similar studies show that retrieval practice can be used in order to improve learning and can therefore well be used in everyday classrooms as part of a learning process rather than mainly as an assessment and evaluation tool (Dunlosky et al., 2013). Using tests for this purpose will affect the way tests are being designed and also the way test results are being dealt with in schools. As testing traditionally is connected to assessment and evaluation, the idea of retrieval practice being a useful tool for learning needs to be discussed with the students. An insight in the possible benefits of using retrieval practice in the learning process could be helpful for teachers as well as students and could be used in the classroom as well as when students are studying on their own.

A form of assessment that has gained increasing interest within education over the last years is formative assessment (Sadler, 1989). Formative assessment is often considered assessment for learning as opposed to summative assessment, considered assessment of learning (Lundahl, 2011). Whereas summative assessment often is used in order to measure prior learning or assign grades, formative assessment aims at using different kinds of classroom assessments in order to guide students towards further learning and help teachers to adapt their teaching according to the students’ needs (Black & Wiliam, 1998). Feedback is accordingly used in order to guide future teaching and learning. Research shows that formative assessment promotes learning (Black & Wiliam, 1998). Although formative assessment cannot be
considered equivalent to retrieval practice, a recent increase in focus on formative assessment in education has led to an update of testing as a tool for learning.

Methodological challenges

Conducting research in the classroom is a challenging task and involves limitations, but also several strengths. One of the most important strengths is that classroom studies provide the opportunity to investigate learning in an authentic setting rather than in a set up laboratory scene for learning. Findings that have been reached in laboratory settings need to be applied in real life settings in order to investigate the generalizability.

However, in a classroom setting there are several factors not controlled for, that could affect the results and decrease an expected effect (Roediger & Karpicke, 2006a). One such potential factor in my studies is that the presentation was being held live, which could imply that there are small differences in the presentation held in twelve separate groups. To account for this and to keep the presentations as identical as possible, a manuscript was used. Likewise, a classroom setting may include unexpected disturbances. This was accounted for in terms of not letting late students enter the room and clear information about how the session should be carried out: the procedure, what was allowed and not, etc. Students arriving late were by another teacher guided to a different room and were given other school related tasks to work on.

In this research I was in charge of both the teaching in all classes and the scoring and analysis of the results. In teaching all the classes the risk of divergent information and content being given to different classes was considered smaller than if different teachers had taught the classes. To minimize the risk of the scoring being affected by my knowledge about different classes or individuals conducting the tests, I was during the scoring process blind to which group the individual participant belonged to and a subsample of the learning tests was also scored by a different, independent rater.

Because the data collection was conducted during the students’ ordinary school day, because it was conducted over a ten week period, and because participation was voluntary, the drop out rate, that is the amount of students missing at least one of the three sessions, was rather high. However, t-tests showed that the mean scores of the two groups (dropout group vs. full attending group) did not differ significantly at any of the tests. I therefore conclude that the drop out rate did not affect the results.
Measuring learning

In the present work, free recall and transfer tests, test types similar to those used by Mayer and Moreno (1998), were used as measurements of learning. The students’ written answers to the questions were analysed in order to calculate learning outcome. Although not showing all aspects of learning, I assume that this measurement gives a fair picture of the students’ learning of the subject content presented.

When studying learning, especially over longer time spans, there are obviously several factors not covered in the studies that may have an effect on the learning outcome. For instance, in the two studies I could control for the amount of time spent on learning the material during the initial session where the time spent on processing the presentation through retrieval practice or restudying was equal for all participants. However, in Study I, I could not control for possible individual processing time spent over the ten week period between the first and the last session. Since the students were informed that they were going to be repeatedly tested, some students might have processed the material individually between the sessions in order to perform well on the tests, especially since the subject content presented in the lecture may have encouraged metacognitive reflection about learning and memory. For students actively spending more time on processing the material on their own, results on the delayed testing may have been affected. A questionnaire dealing with time spent on the material between the sessions could have been given to the students after the last session to control for this factor. However, results from such a questionnaire may not have reflected the students’ actual thinking processes between the sessions, due to for instance the difficulty in recollecting thought processes over a ten week period. Since all participants had the same information, students working with the material in between the sessions were probably randomly placed in the different classes. The risk of individual study time between the sessions affecting the results in terms of effects and interactions is therefore considered rather moderate. I also could not control for students from different classes discussing the various learning conditions and presentation formats with each other. However, knowing that the classes belong to different national programs with only limited cooperation in general, the risk of this factor affecting the results in terms of effects and interactions is also considered rather moderate.

What would also have been interesting to investigate further alongside learning style, is the students’ approaches to learning the content covered (deep vs surface approach, as described by Marton & Säljö, 1976), as approaches to learning may affect the way the material is dealt with and learnt. However, this was not covered in the present work, but may be developed in future studies.
Concluding remarks

My research extends earlier research in that it combines two robust learning strategies and shows that in the present dataset and with the present subject content, multimedia learning clearly fares better than retrieval practice. Also, it shows that multimedia learning holds in classrooms situations, over longer time spans and with material from the social sciences. It also suggests that the multimedia instruction hypothesis holds independently of preferred learning style, which renders strong support for the hypothesis in terms of its generalizability.

The results provide valuable input to both teachers and students and can be seen as a contribution to the very complex work of creating possibilities for an evidence-based teaching, as stated in the Swedish Educational Act (SFS 2010:800). The results also pose challenges for students and teachers, as well as people designing course books and other learning materials, concerning how to approach the use of visual illustrations and retrieval practice in teaching and learning.

The empirical studies in this thesis only investigate learning psychology in upper secondary school and need to be replicated with for instance younger students, different subject content and children with diagnosed learning difficulties in order to address the full potential of these findings for teaching and learning. Also, future studies ought to further look into possible synergetic effects in combining different learning strategies (Kornell et al., 2012). Furthermore, it would be worthwhile looking into qualitative differences in recall and transfer when visuoverbal rather than verbal presentations and retrieval practice rather than restudying is being used. Also, a suggestion for future studies is to investigate retrieval practice of the visual component more specifically. As noted by several other researchers, more investigation ought to be conducted concerning learning styles and its possible implications before it is further implemented in educational practice (Cassidy, 2004; Curry, 1990; Pashler et al., 2008).

To conclude, a picture does not always say more than a thousand words. However, the combination of pictures and words seems to be a way forward in teaching psychology. Comenius (1887) may have touched upon something when he concluded that “there is nothing in our understanding that was not before in the sense”…


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57


The Effect of Visual Illustration and Retrieval Practice When Learning Psychology

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Abstract

It is well established that studying with (vs. without) visual illustrations as well as taking tests (vs. restudying) is beneficial for learning, but on which strategy should one put the efforts, or should they be combined for best learning? Upper secondary school students were given a lecture presented verbally or with the aid of a visual illustration. The information was processed again by taking a memory test or by restudying. Recall and transfer tests were conducted after some few minutes and again after one and 10 weeks. The lecture including a visual illustration resulted in better learning than verbal presentation only. A modest effect of memory testing was found. However, the effect was considerably weaker than, and did not improve memory performance beyond, the beneficial effect of using a visual illustration. When teaching, it is worthwhile using visual illustrations and memory testing to improve learning, although the former is better.

Keywords: multimedia effect, testing effect, visual illustration, retrieval practice, learning
Introduction

Much teaching and learning research has focused on students’ cognitive activities when they study (see Hacker, Dunlosky, & Graesser, 2009; Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013, for reviews). In the present work we compared two robust learning strategies in an applied setting, namely multimedia learning and retrieval practice (see Mayer, 2009; Roediger & Karpicke, 2006a, for reviews). Multimedia learning refers to people learning and remembering better when a text or lecture is combined with pictures than from words alone (Paivio, 1986). Retrieval practice refers to memory testing as a learning strategy which often leads to better long-term recall than, for example, restudying. The latter benefit in favour of retrieval practice is often referred to as the testing effect (Roediger & Karpicke, 2006a). Both these methods have, when investigated in isolation from each other, proven rather robust. However, for teachers and students to be able to make informed decisions about how to best improve learning, it is important to compare learning strategies that are known to be effective (see Kornell, Rabelo & Klein, 2012, for a similar argument), and in everyday teaching many different teaching tools are used in combination. For example, most testing effect studies have compared testing to exact repetition, a learning strategy known to be ineffective. It is therefore important to study the two effects, both considered effective, together, and in particular in a classroom setting.
Much of the previous multimedia learning and retrieval practice research has been conducted in laboratories or with computers as the teaching tool, focusing on material from the natural sciences or mathematics (Kartal, 2010; Mayer & Moreno, 1998; Roediger & Karpicke, 2006a). In the present study, we used an authentic classroom situation, and material from the social sciences. More precisely, we investigated to what extent studying with or without visual illustrations as well as taking tests (vs. more study time) influence learning of psychological concepts in the classroom. We investigated both recall and transfer effects across three retention intervals up to 10 weeks and were particularly interested in to what extent the two effects enhance each other, that is, should the teacher combine these two strategies in the classroom?

**Multimedia Learning**

*The multimedia instruction hypothesis* states that people learn better from words and pictures presented together (i.e. visual illustrations of what is presented verbally) than from words alone (Paivio, 1986; Mayer, 2011b), and the effect is referred to as the multimedia effect. The hypothesis is derived from *dual coding theory*, according to which information is processed in two different channels, a verbal and a visual (Paivio, 1986; Mayer, 2009). Verbal and pictorial representations are being built and integrated when words and pictures are presented simultaneously (Mayer & Anderson 1992; Mayer, 2011b) and when presented in different modalities, that is, when
words are presented auditorily rather than visually (Mayer & Moreno, 1998; Moreno, Mayer, Spires, & Lester, 2001). The latter assumption refers to the risk of overload in the capacity-limited visual working memory if all information initially is processed visually (Mayer & Moreno, 1998). In a series of three experiments where students were presented with the process of lightning, Mayer and colleagues (1996) showed that students who were presented the information with a visual illustration performed better on both recall and transfer tests compared to students who were presented the information in written text only. In accordance with these findings, Rundgren and Tibell (2009) argued that visualisations have proven to be important cognitive aids in order to better understand complex processes of cellular events in science teaching. In the present study we compared an oral presentation (a short lecture) with one where also a visual illustration was included, expecting that the latter condition would lead to better learning.

**Retrieval Practice**

*The testing effect*, according to which there are clear benefits of retrieval practice when learning new material compared to only restudying the material, implies that tests could be used to improve student learning, not only assessing it (Gates, 1917; Spitzer, 1939; Rawson & Dunlosky, 2012; Dunlosky et al., 2013; Roediger & Karpicke, 2006b). If the student during the initial learning is actively working with the material, that is producing rather than recognising or re-studying the material, it is better recalled (Schwartz,
Son, Kornell, & Finn, 2011; Roediger & Karpicke, 2006a). Bjork and Bjork (1992) proposed that in the active process of retrieval, the elaboration of the memory trace is being increased, as are the retrieval routes to this trace. The testing effect has been shown with a variety of materials, such as word-lists (Bouwmeester & Verkoeijen, 2011), foreign language vocabulary or paired associates (Carpenter, Pashler, Wixted, & Vul, 2008; Jönsson, Hedner, & Olsson, 2012), prose passages (Roediger & Karpicke, 2006b), general knowledge facts (Butler, 2010; Carpenter et al., 2008), video lectures (Butler & Roediger, 2007), maps (Carpenter & Pashler, 2007) and visuospatial information (Kang, 2010) etc. However, the positive effect of retrieval practice on recall, when given without feedback, is typically seen after longer retention intervals, but not necessarily on immediate recall tests (e.g., Toppino & Cohen, 2009), with less forgetting over time in the testing condition compared to a restudy condition. The testing effect has shown to be robust across materials, including multimedia material (Johnson & Mayer, 2009; Butler & Roediger, 2007; Kang, 2010; Carpenter & Pashler, 2007), wherefore we expected to find the effect in the present study as well.

Learning, recall and transfer

The overall aim of education is learning. To reach meaningful learning, both recall and transfer need to be taken into account (Mayer, 2009). Learning is in the present study, and in line with Mayer’s definition (2009), seen as a combination of recall and transfer. Recall is defined as remembering,
that is, the ability to reproduce or recognize previously presented material (Mayer, 2009). Transfer has been defined in slightly different ways and is not a unitary phenomenon (Salomon & Perkins, 1989). Butler (2010) and Mayer (2009) defined transfer as the ability to use presented material in different contexts or situations and Rohrer, Taylor, and Sholar (2010) as a novel demonstration of learning. Carpenter (2012) defined it as an application of knowledge and Salomon and Perkins (1989) as displaying learning on some other occasion, however similar. In the present study we define transfer similarly to Salomon & Perkins (1989, p. 5), who defined it as the “effect of learning something on a different performance or context”. However, in this study we focus on a different performance rather than context.

Multimedia learning researchers often distinguishes between recall and transfer and in most studies both aspects seem to be improved by the use of visual illustrations (Mayer & Andersson, 1992; Mayer, Bove, Bryman, Mars, & Tapangco, 1996; Johnson & Mayer, 2009; Rundgren & Tibell, 2009). There is also some evidence that retrieval practice benefits not only recall, but also transfer (Butler, 2010; Carpenter, 2012; Karpicke, 2012; Rohrer et al., 2010). In the present study we analyse both recall and transfer scores.

An aspect uniting many of the multimedia learning studies is that longer retention intervals are seldom being used (Mayer & Moreno, 1998; Mayer et al., 1996; Mayer & Anderson 1992; Kartal, 2010; Seufert et al., 2009; Ozcelik et al., 2010; Harskamp et al., 2007). There are examples of testing effect
studies with longer time spans (McDaniel et al., 2007; Carpenter et al., 2008; Roediger et al., 2011; Carpenter et al., 2009; Leeming, 2002; Butler & Roediger, 2007; McDaniel et al., 2011), although most studies have shorter retention intervals. Since an aim of education is to learn and remember for longer periods of time, the present study included retention intervals up to 10 weeks.

**Multimedia learning and the testing effect in the classroom**

There are several vital differences between the laboratory and the classroom, which implies that in order to understand the different aspects of multimedia learning, the testing effect and their practical applications for education, it is critical to conduct studies in an authentic classroom setting as well as in lab settings (Roediger & Karpicke, 2006a; McDaniel, Anderson, Derbish & Morrisette, 2007; Miller, 2011; Harskamp, Mayer, & Suhre, 2007). Much multimedia learning and testing effect research has been conducted in laboratories and/or with computers as the teaching tool (Mayer & Moreno, 1998; Mayer et al., 1996; Mayer & Anderson, 1992; Harskamp et al., 2007; Ozcelik, Arslan-Ari, & Cagiltay, 2010; Seufert, Schutze, & Brunken, 2009; Kartal, 2010; Roediger & Karpicke, 2006a). With some exceptions (Moreno & Valdez, 2007; Herrlinger, 2012), classroom studies are not easily found in previous multimedia learning research, although more such studies have been carried out in relation to the testing effect (e.g., Leeming, 2002;

In a meta-analysis of 35 classroom studies concerning the testing effect, Bangert-Drowns, Kulik and Kulik (1991) showed that in 29 of the studies, retrieval practice had a positive effect on learning compared to the control condition, in five cases retrieval practice had a negative effect and in one there was no difference between retrieval practice and the control condition. In more recent studies both Leeming (2002) and McDaniel and colleagues (2007) found that by using frequent quizzes during a college course, the students reached better results than did students who were not frequently tested. Vojdanoska, Cranney, and Newell (2010) found evidence for the benefits of retrieval practice in a tertiary educational setting and Cranney, Ahn, McKinnon, Morris, and Watts (2009) found that students who had taken a test in the initial phase proved better long-term recall of the material tested than did students who had only re-studied the material. Rohrer and colleagues (2010) found similar results with 4th and 5th graders learning cities on a map, as did Carpenter, Pashler, and Cepeda (2009) and McDaniel and colleagues (2011) when 8th graders were to learn history and science. In sum, most of the testing effect studies conducted in a classroom setting, point to the replicability of the testing effect also in authentic educational settings.

Studies on multimedia learning carried out in the classroom present somewhat contradicting results. Moreno and Valdez (2007) found that when
learning teaching principles, teacher students who were presented classroom cases on a video performed better recall and transfer than students who were presented the same classroom cases in written text. However, Herrlinger (2012), who carried out two experiments with primary school children learning about the blood circulation system, did not find a multimedia effect. Similarly, in a study with 190 university students studying educational sciences, Westelinck and colleagues (2005) did not find that the use of visual representations resulted in higher test performance. They argued that the multimedia effect is not generally applicable in the social sciences. In contrast to the natural sciences, where most multimedia learning studies have been conducted, the graphical representations in the social sciences are not naturally built on a consensual iconic sign system previously acquired or mastered by the students. They argued that representations in the field of natural sciences are, more commonly than in the social sciences, intuitive and depictive in nature. Hence, the issue of multimedia learning in the social sciences need further attention and the material used in the present study was a memory model from the upper secondary psychology course.

**The aim of the present study**

The overall aim of this study was to increase the understanding of how students learn a verbal description of an abstract psychological phenomenon, with or without the help of visual illustration and/or testing. The study was carried out in an authentic classroom environment, with a material based on
content from the social sciences and with a long retention interval (i.e. up to 10 weeks). More specifically we were interested in investigating (i) to what extent multimedia learning has an influence on recall and transfer in learning psychology, (ii) to what extent retrieval practice (vs. restudy) influences recall and transfer in learning psychology, and (iii) on which strategy should one put the efforts or should they be combined for best learning?

The present study is the first to investigate the combined effect of multimedia learning and retrieval practice, and it is therefore more explorative in nature. However, given that multimedia learning and retrieval practice likely entails different kinds of processing, the two learning strategies should uniquely contribute to learning. More precisely, multimedia learning presumably activates encoding processes whereas testing is thought to activate retrieval processes. For this reason, we tentatively expected learning to benefit from a combination of the two.

**Method**

**Participants**

One hundred and thirty-three students, 69 female and 64 male adolescents, were recruited from five national programs in three different upper secondary schools in Stockholm, Sweden. They were all second graders and the average age was 17.3 years ($SD = .54$). An additional nine students participated in the initial learning session, but were removed due to not follow-
ing instructions and/or for scoring zero on the immediate memory test. Eighty-eight of the 133 students participated in all three memory tests.

**Design**

A 2 x 2 x 2 x 3 mixed design was used. Presentation format (verbal presentation vs. visuoverbal presentation) and study strategy (restudy vs. retrieval practice) were manipulated between-subjects, and test type (recall vs. transfer) and retention interval (immediate vs. one week vs. 10 weeks) were manipulated within-subjects. Test performance, in terms of recall or transfer, was the dependent variable.

**Materials**

The to-be-learned material consisted of the Atkinson-Shiffrin memory model (Atkinson & Shiffrin, 1968), which was presented either only orally or both orally and visually. Both the oral presentation and the visual illustration were derived from two high school textbooks in psychology (Fälldt, 2003; Smith, 1999) and outlined the flow from sensory memory, to short-term memory and to long-term memory. The visual illustration included all different steps in the orally presented process and was, as in most introductory psychology textbooks, presented through boxes and arrows combining them.

Two types of tests were used, a recall test consisting of one open-ended question and a transfer test consisting of five questions, test types similar to those used by Mayer and Moreno (1998). Issues mentioned in the transfer
questions were not discussed in the presentation. See the Appendix for a complete list of questions.

The participants filled in a questionnaire about their age and sex and received questions about their previous knowledge about the structure of the memory. The participants also completed the Mental Effort Tolerance Questionnaire (METQ; Dornic, Ekehammar, & Laaksonen, 1991) and the Modified Associative Learning test (MAL; Lövdén, 2003), measuring the participants’ working memory. In addition, but not further analysed or discussed in the present work, the participant’s also filled in the Style of Processing questionnaire (SOP; Childers, Houston, & Heckler, 1985), which measures learning style, and received questions about their attitudes towards the material presented (i.e., how interesting it was, how difficult it was to learn, as well an estimation of how much of the presented material will be remembered after one week and 10 weeks respectively).

**Procedure**

The participants were tested in 12 already existing classes, with an average size of 12 students (range: 8-15). First, brief instructions about the session were given and the participants were asked to fill the questions about their age and sex, as well as questions about their previous knowledge about the structure of the memory. Second, the presentation about the structure of the memory was being held, without interaction from the participants. The presentation was 6 minutes long and was held in the classroom by the same
presenter in all classes (the first author). For six of the classes, the presenter simultaneously drew the visual illustration on the white board, whereas the other six classes only received the verbal presentation. The classes were randomly assigned to one or the other presentation format. Third, the participants completed the METQ-questionnaire. Fourth, the students in each class were randomly assigned to one of two study strategy conditions (restudy vs. retrieval practice) with an even allocation between the variable levels. All students were given 10 minutes to work with the material presented. The restudy group was instructed to study a written manuscript of the verbal presentation and the retrieval practice group was asked to write down the answer to the recall question (see section 6.1.1 in the Appendix). Fifth, the participants answered questions concerning their attitudes towards the material presented and completed the SOP-questionnaire. Finally, the students were asked to answer the recall question (8 minutes) and the five transfer questions (3 minutes each). Each question was presented on a separate sheet and the answers were written by hand on the same sheet as the respective question. Participants were told that a follow-up would be done one and ten weeks later.

One week later the groups were asked to complete the same recall and transfer test. Finally, ten weeks later, they completed the transfer and recall test one final time, after which they took a memory test (MAL) where they were asked to memorize two lists of word pairs.
Scoring

When scoring, the raters were blind to which group the individual participant belonged to. Two independent raters scored a subsample (10%) of the same data (recall and transfer) and the inter-rater reliability was very high ($r = .99$ for recall and $r = .94$ for transfer), wherefore only one of the raters (the first author) scored the remaining data. On the recall test, one point was given for each of the main ideas presented in the verbal presentation: stimuli, the sensory memory, selective perception, the short term memory, the use of repetition, encoding, the long term memory, associations, organising, and the need for retrieval. Scores were not given for vague answers, but for answers worded differently from the verbal presentation. An acceptable answer concerning sensory memory would for instance be in terms of the different senses. An acceptable answer concerning selective perception would be what one focuses on. The recall scores were calculated into proportions. The transfer test consisted of five questions with a total of 19 acceptable answers and dealt with issues such as why one forgets, why repetition is good and possible problems with an injured short-term memory. The transfer questions were not explicitly discussed in the verbal presentation. One point was given for each acceptable answer and the scores on the different transfer questions were summed and computed into a proportion. When analysing scores from recall and transfer tests combined, a mean proportion of the two test scores was calculated.
Results

Background analysis

To investigate whether the classes differed in any respect we entered class as the independent variable and self-rated previous knowledge, The MAL score and the METQ score as the dependent variable in three separate ANOVAs. The participants’ self-rated previous knowledge about the to-be-learned material was limited and did not differ significantly between the classes \((p = .14)\). The classes also did not differ in terms of the participants’ working memory, as measured with the MAL test \((p = .91)\), or tolerance for mental effort, measured with the METQ questionnaire \((p = .64)\).

Dropout analysis

Because of the relatively large dropout from the immediate testing occasion until the final test 10 weeks later, we analyzed whether the dropouts differed from those that remained in the study across all retention intervals. First, an independent samples t-test showed that, at the immediate test, the mean performance of the group that failed to attend one or both of the later test occasions \((n = 45)\) and the full attending group \((n = 88)\) did not differ significantly \((t < 1)\). Second, because the dropout rate was negligible at the second retention interval (1 week), we also compared the results of the ANOVA with \((n = 88)\) and without \((n = 116)\) the final 10 week retention interval, to see if any of the conclusions made on the basis of any of the two
analyses differed. With one exception, the effects did not differ in terms of statistical significance (alpha = .05) as a function of whether 2 or 3 retention intervals were included in the analysis. The exception was that the study strategy by retention interval interaction was only marginally significant ($p = .051$) when all three retention intervals were included, compared to when only two retention intervals were included ($p = .01$; see section 3.3.2). To conclude, the dropout rate is unlikely to have affected either the results or the conclusions we make in the present study.

**Learning**

In order to analyze how retrieval practice and the use of visual presentation affect learning, the results from the final test performance was entered into a presentation format (verbal vs. visuoverbal) x study strategy (restudy vs. retrieval practice) x retention interval (immediate vs. one week vs. 10 weeks) x test type (recall vs. transfer) mixed factorial ANOVA.

**Multimedia learning.** We replicated the multimedia effect as seen in a significant main effect of presentation format, $F(1, 84) = 12.47$, $MSE = 1.46$ $p < .001$. The combined presentation of visual and verbal information resulted in better learning, that is, significantly higher test scores on the three test occasions, compared to only verbal presentation (visuoverbal: $M = .52$, $s = .14$; verbal: $M = .41$, $s = .14$, $d = .79$). An interaction between presentation
format and retention interval, $F(2, 84) = 6.54$, $MSE = 0.07$, $p = .002$, was mainly driven by the difference between the verbal and the visuoverbal groups on the immediate test, $t(86) = 5.16$, $p < .001$, $d = 1.13$ as evident in Figure 1. However, the difference remained reliable also after a week, $t(86) = 2.39$, $p = .019$, $d = 0.51$, and after 10 weeks, $t(86) = 2.34$, $p = .022$, $d = 0.50$. To conclude, visuoverbal presentation resulted in reliably better learning in both a short- and long-term perspective.

*Figure 1.* Proportion correct answers across the three retention intervals for the verbal presentation only and visuoverbal presentation groups respectively. Error bars represent the standard errors.

**Retrieval practice.** A testing effect was found in terms of a lower forgetting rate over time for the retrieval practice group compared to the restudy group. This can be seen in the marginally significant study strategy by reten-
tion interval interaction, $F(2, 84) = 3.04, MSE = 0.03, p = .051$, and as shown in Figure 2. Due to the dropout from the 10 week test, and as noted in section 3.2, we also ran the same ANOVA for the first two retention intervals only. By excluding the third retention interval, and thus increase the number of the participants and the statistical power, the study strategy by retention interval interaction was clearly significant, $F(1, 112) = 6.82, MSE = 0.08, p = .012$, underscoring the finding that testing led to less forgetting than study-only.

However, simple effects tests showed no reliable difference at any retention interval ($ps > .20$). There was no main effect of study strategy ($F<1$), but expectedly a main effect of retention interval $F(2, 84) = 13.25, MSE = 0.15, p < .0001$, proving that the students forget over time. In sum, although we did see a positive benefit of retrieval practice in terms of less forgetting (i.e., the interaction effect), retrieval practice actually never lead to better memory than restudy, not even after 10 weeks.
Figure 2. Proportion correct answers across the three retention intervals for the restudy group and the retrieval practice group, respectively. Error bars represent the standard errors.

**Do the multimedia and testing effects enhance each other?**

There was no statistically significant interaction effect between study strategy and presentation format ($F<1$), nor an interaction between study strategy, presentation format and retention interval ($F<1$). This means that retrieval practice did not reliably improve the participants’ memory performance beyond the beneficial effect of visuoverbal learning. Hence, at least in the present study, presentation format proved to be a more important factor for learning (i.e. higher test scores) than study strategy. Retrieval practice led to some decrease in the forgetting rate, but the fact that it did not lead to...
reliably better memory at any retention interval, whereas this was consistently the case for multimedia learning, shows the robustness of the multimedia effect.

![Graph](image)

Figure 3. Proportion correct answers across the three retention intervals as a function of presentation format (verbal only vs. visuoverbal) and study strategy (restudy vs. retrieval practice). Error bars represent the standard errors.

**Differences between recall and transfer**

As shown in Figure 4, there was a reliable test type by retention interval interaction, $F(2, 84) = 10.24$, $MSE = 0.08$, $p < .001$, showing that there was forgetting rate over time for recall, but not for transfer. To further analyse this interaction we made two separate presentation format x study strategy x
Retention interval mixed factorial ANOVA:s for the recall and the transfer data, respectively.

**Multimedia learning.** The multimedia effect was found robust in terms of both recall ($d = 0.73$) and transfer ($d = 0.64$), as seen in a main effect of presentation format for the recall test, $F(1, 84) = 11.74, MSE = 0.99, p < .001$ as well as for the transfer test $F(1, 84) = 9.24, MSE = 0.51, p = .003$. Accordingly, using a visuo-verbal presentation format, compared to verbal presentation only, was in this study clearly proven better for learning in terms of both recall and transfer.

**Retrieval practice.** No reliable main effect of study strategy was found for recall ($F < 1$) nor for transfer ($F = 1.02$), meaning that as an average across the retention intervals, testing failed to show an advantage over re-study for both test types. However, a study strategy by retention interval interaction was found for the recall data, $F(2, 84) = 3.08, MSE = 0.03 p = .048$, but, most interestingly, not for the transfer data ($F < 1$). The lack of a testing effect in terms of transfer contrasts some previous research (Butler, 2010; Rohrer et al., 2010; Carpenter, 2012; Karpicke, 2012).

**Test type by retention interval interaction.** As noted, a significant interaction between test type and retention interval found in the four-way ANOVA (Figure 4). Most interestingly, the three-way ANOVA with transfer as the dependent variable showed no main effect of retention interval ($F < 1$). The understanding of the content learned did not significantly change across
the 10 weeks retention interval. In contrast, recall showed reliable forgetting across the 10 week retention interval in terms of a main effect of retention interval, $F(2, 84) = 19.52$, $MSE = 0.22$ $p < .001$, where the recall rate decreases over the 10 week period (see Figure 4). This finding was unexpected.

Figure 4. Proportion correct answers across the three retention intervals for the recall and transfer test, respectively. Error bars represent the standard errors.

General Discussion

We investigated to what extent studying with or without visual illustrations as well as taking tests (vs. restudying) influence learning of psychological concepts in the classroom, both separately and in combination. Further, we investigated the effect of these manipulations on both recall and transfer
effects across retention intervals up to 10 weeks. Consistent with previous multimedia learning research (Paivio, 1986; Mayer, 2011b; Mayer et al., 1996; Moreno & Valdez, 2007), a visuoverbal presentation resulted in better learning than verbal presentation only. Further, the multimedia effect was replicated for both recall and transfer. A testing effect was found in terms of a lower forgetting rate over time for the retrieval practice group compared to the restudy group (i.e., the interaction effect), but the retrieval practice group never outperformed the restudy group, not even after 10 weeks. Also, an interaction effect was found between retention interval and test type in that the transfer rate, in contrast to the recall rate, did not significantly change across the 10 weeks.

The results show that the multimedia effect holds in an authentic classroom setting and over a longer time span, aspects not vastly investigated, but highly relevant for educational practice. The results contradicts the findings by Westelinck and colleagues (2005), in suggesting that the multimedia effect replicates for visual illustrations also within the social sciences, in this case psychology (see also Cranney et al., 2009; Vojdanoska et al., 2010, Carpenter et al., 2009; Roediger et al., 2011). It may sometimes be a larger challenge to create good visual illustrations in the social sciences than in the natural sciences, as based on Westelinck’s (2005) argumentation, but the present results clearly show that the social sciences are not excluded from the effect of multimedia learning.
A typical finding is that after a short retention interval memory performance in a study-only condition is either better or comparable to that of a testing condition without feedback, but testing trumps study-only after a longer delay (e.g., Toppino & Cohen, 2009). Although a testing effect was found in the present study in terms of the retrieval practice group forgetting less over time than the restudy group, it is also important to note that the retrieval practice group never outperformed the restudy group on the delayed testing, not even after 10 weeks. Further, the study strategy by retention interval interaction was found for recall but not for the transfer test only, in contrast to some earlier research (Carpenter, 2012; Karpicke, 2012; Butler, 2010; Rohrer et al., 2010). One possible reason why the benefits of retrieval practice were not as robust as shown in several other studies (Leeming, 2002; McDaniel et al., 2007; Vojdanoska et al., 2010; Cranney et al., 2009; Rohrer et al., 2010; Carpenter et al., 2009; McDaniel et al., 2011) could be the lack of feedback, as feedback seems to strengthen the testing effect (Pashler, Cepeda, Wixted, & Rohrer, 2005; Butler & Roediger, 2007). Another possible reason for the non-robust testing effect could be that only one practice test session was used. Roediger and Butler (2011) argued that memory performance generally increases after repeated test sessions. However, since one of the aims was to carry out the study in an authentic classroom environment mimicking traditional lectures, using the still quite uncommon procedure of repeated retrieval could in itself have confounded the
results (an observer effect). In an authentic school setting there are, in addi-
tion, several factors not controlled for, that could affect the results and de-
crease an expected effect (Roediger & Karpicke, 2006a). Furthermore, the
fact that all students took the same tests three times over the 10 week period
could decrease the magnitude of the testing effect, since the conditions be-
come more and more similar over time. However, despite those aspects, a
significant testing effect, in terms of the retrieval practice group forgetting
less than the restudy group, was found.

In the light of the results showing a robust multimedia effect but only a
very modest testing effect, it is not surprising that the two effects did not
enhance each other. Retrieval practice did not reliably improve the partici-
pants’ memory performance beyond the beneficial effect of visuoverbal
learning. It is possible that we could have found synergistic effects of the
two learning strategies by addressing some of the potential limitations of the
present study, and if we would have been successful in replicating a strong
testing effect. Because multimedia learning and retrieval practice likely en-
tails different kinds of processing, the two learning strategies should possibly
uniquely contribute to learning. More precisely, multimedia learning pre-
sumably activates encoding processes whereas testing is thought to activate
retrieval processes. The present study gives reason to conclude that multi-
media learning is an even more robust learning strategy than retrieval prac-
tice.
It is interesting and a bit surprising that the transfer rate did not significantly change across the 10 weeks retention interval (i.e. no forgetting in terms of transfer), as did the recall rate. These results seem to suggest that the students forgot facts and details over time, but that the understanding of the content still remained after the 10 weeks. A possible explanation could be that some of the fact details had been encoded more shallow and were thus forgotten over time, whereas the understanding of the content had been processed more deeply, creating more durable memory traces (Craik & Lockhart, 1972).

Traditional school instruction tends to favour verbal (auditive or written) rather than visual modes of presentation (Mayer, 2011b). Likewise, tests have tended to mainly be used as tools of summative assessment and evaluation of learning (Dunlosky et al., 2013; Vojdanoska, 2010). The findings of our and similar studies show that visual presentations, as well as tests, can be used in order to improve the learning process (Mayer, 2011b; Dunlosky et al., 2013). The developing of visual representations is not an easy task and many aspects need to be taken into consideration in order to create well-functioning visual representations (Mayer, 2011a). Nevertheless, it seems worthwhile to put effort into creating such representations in order for students to even better learn and process new information. This should be the case in everyday classroom teaching as well as in textbooks used in schools. Since the effect of visuoverbal presentations seems to be so robust, creating
and using visual representations for teaching and learning ought to be prioritized. Also, using retrieval practice as a way of improving learning means that tests should be viewed as a possible part of a learning process rather than mainly an assessment and evaluation tool. Naturally this will affect the way tests are being designed and used. The benefits of using retrieval practice in the learning process may therefore be an important insight for both learners and educators.

This study only investigated learning in emerging adulthood. In order to address the full potential of these findings for teaching, they need to be replicated and extended to for instance younger participants and children with diagnosed learning difficulties. Also, future research need to further look into the combination of different learning strategies and possible synergetic effects (Kornell et al., 2012). More research also needs to be conducted in authentic educational situations, with collaborative student-teacher interaction (in combination with student-computer interaction) and with different subject contents (Nouri, in press). In addition, it would be worthwhile looking into qualitative differences in recall and transfer when visuo- verbal rather than verbal presentations and retrieval practice rather than restudying is being used. Also, a suggestion for future studies is to investigate retrieval practice of the visual component more specifically. Requiring the participants to practice retrieval by both short answer responses (writing down the answers) and drawing the visual representation from memory could further boost the
learning effects. Short answers are useful practicing retrieval because the student must actively retrieve and produce an answer (Roediger et al., 2011). Drawing a visual representation from memory also demands active engagement from the student and could potentially enhance performance additionally.

Our research extends earlier research in that it combines two robust learning strategies and shows that in the present dataset multimedia learning clearly fairs better than retrieval practice. Also, it shows that multimedia learning holds in authentic classrooms situations, over longer time spans and with material from the social sciences. The study provides important information to both teachers and students.

References


Appendix

Recall question used

Describe how the memory works. Imagine that you describe it for someone who does not know much about it and bring in all you can remember from the presentation.

Transfer questions used

1) How could you, according to the structure of the memory and how the memory works, explain why one forgets? Explain in as much detail as you can.

2) What would happen to the function of the memory if the short-term memory was ‘injured’ or stopped working?

3) Why could it be difficult to remember what a person wore when you met him/her a couple of days earlier, even though you remember exactly what the person did or said? Explain in as much detail as you can based on the structure of the memory and how the memory works.

4) Why, according to the structure of the memory, is repetition such a good thing when you should remember something?

5) What problems could arise with the function of the memory if the long-term memory was ‘injured’ or stopped working appropriately?
Who benefits from visual illustrations in psychology teaching – A question of learning style or a more general principle?

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Abstract

A key question concerning the use of visual illustrations in teaching is whether teaching should be adapted according to students’ preferred learning style (verbaliser - visualiser), or whether focus should be on a strategy that works well in general, independent of preference (multimedia learning), in order to further improve student learning. Upper secondary school students were given a short lecture presented only verbally or with the aid of a visual illustration, followed by a test of how much they had learnt. Their self-rated learning style was measured with the Swedish version of the Style of Processing questionnaire (SOP; Kalén, Maynard, Svensson & Östergren, 2002). Visouverbal presentation resulted in better learning than verbal presentation only, independently of learning style. Support was not found for the learning styles hypothesis. Interestingly, students with mixed or visual learning styles performed generally better on the learning test than students with a verbal learning style, which could imply that it is worthwhile to help students develop a preference for visual or multimodal aspects of information processing in order to further improve learning. Since the use of visual illustrations seems to have a beneficial effect on learning for most students, this mode of instruction ought to be used in psychology teaching for the age group and content tested.
Introduction

The idea that individuals’ learning styles are important to take into account when adapting classroom methods has reached wide popular acceptance within the educational field and among the general public (Riding & Cheema, 1991). The learning styles hypothesis suggests that people learn information in different ways and that individuals differ in terms of what mode of instruction or study is most effective for them (Dunn, Beaudry & Klavas, 2002; Riding & Rayner, 2005). Teaching methods should according to this idea be adapted to the individual student’s preferred mode of learning, since learning style in most studies focuses on the individual’s preference rather than ability (Childers, Houston & Heckler, 1985; Pashler, McDaniel, Rohrer & Bjork, 2008). Riding and Cheema’s (1991) categorisation of learning styles in terms of a verbaliser – imager dimension suggests that some people may prefer, and should thus benefit more than others, from the use of a visual illustration, or from primarily verbal encoding. However, criticism has been raised concerning the lack of evidence for the learning styles hypothesis (Pashler et al., 2008).

Another approach to learning, not based on individual differences in students’ preferences, is multimedia learning, which has proven to be a robust learning strategy (Jägerskog, Jönsson, Selander, & Jonsson, 2015; Mayer,
The core assumption of the multimedia instruction hypothesis is that people learn better from words and pictures combined than from words alone (Mayer, 2010; Paivio, 1986), indicating that this applies to people in general. However, studies focusing on the effects of different presentation formats in teaching often do not take into account the role of individual differences (Kollöffel, 2012). A key question thus becomes whether teachers in their efforts to further improve student learning should adapt their teaching on the basis of students’ preferred learning style (verbaliser - visualiser) or whether they should instead focus their efforts on a strategy that works well for most students, independent of preference (multimedia learning). The present study aimed to investigate this in order to draw conclusions about possible implications for teaching.

Learning styles

The learning styles term came into use when research on cognitive styles (Allport, 1937) was turned towards pedagogy and the classroom, matching course presentation and materials to the need of each individual learner (Cassidy, 2004; Kirby, 1979; Rayner and Riding, 1997). Several decades of learning style research has made the field rather disparate, fragmented and elusive, with the development of a large variety of concepts, definitions, style labels and assessment instruments (see De Bello, 1990; Riding, 1997; Riding & Cheema, 1991 and Swanson, 1995 for reviews). Learning style is in the present study seen as an individual’s way of perceiving, processing
and recalling information, focusing on the individual’s preference rather than ability (see Scarpaci and Fradd, 1985; De Bello, 1990; Childers et al., 1985; Pashler et al., 2008, for a similar definition). The learning styles hypothesis suggests that in order to optimize each student’s learning, instruction should be provided in a way that matches each individual’s learning style, as typically measured with a diagnostic test instrument (Pashler et al., 2008; Rayner, 2001; Riding & Rayner, 2005).

It is uncontroversial that the optimal mode of instruction differs in some respects between individuals, due to for instance educational background, prior knowledge and cultural differences (Clark & Feldon, 2010; McNamara, Kintsch, Songer, & Kintsch, 1996; Pashler et al., 2008). Likewise, there is evidence for the existence of learning styles in terms of instructional and processing preference, and for a significant correlation between a student’s learning style and his/her choice of instructional mode in the learning situation (Alesandrini, 1981; Childers et al., 1985; Massa & Mayer, 2006; Pashler et al., 2008; Ramsey & Deeter-Schmelz, 2008; Riding & Watts, 1997). However, this does not necessarily mean that a student actually learns better through his/her preferred learning style or that it is meaningful for educators to take individual learning styles into account (Kollöffel, 2012; Pashler et al., 2008). Indeed, research on memory and metacognition shows that our intuitive beliefs about how we best learn are often wrong (Pashler et al., 2008;
In a meta-analysis of 39 learning style studies, Kavale and Forness (1987) initially found results indicating a small impact of learning style on the students’ learning. However, when studies with methodological problems were excluded from the meta-analysis, such as studies with lesson plans differing in more aspects than the mode of instruction, the modality effect disappeared. Similarly, Pashler and colleagues (2008) concluded that it is hard to find learning styles studies that do not have methodological problems and the studies that don’t have such problems seem to contradict the learning styles hypothesis (e.g., Constantinidou & Baker, 2002; Kollöffel, 2012; Massa & Mayer, 2006). Obviously those and other similar studies do not imply a conclusive refutation of the learning styles hypothesis, however, more appropriately carried out research providing proof for the hypothesis is needed in order to find reasons to apply learning styles in the general educational practice (Cassidy, 2004; Curry, 1990; Pashler et al., 2008; Willingham, 2005).

Pashler and colleagues (2008) suggest that convincing support for the learning styles hypothesis would demand a crossover interaction. This means that the learning styles hypothesis will be supported if, and only if, the learning method that optimises learning for students with one learning style is different from the method optimising learning for students with another
learning style. In terms of the present study, this would mean that visualisers should perform better in a visual condition than verbalisers and vice versa.

**Learning styles and the verbaliser - visualiser dimension.** The instrument used in the present study measures so called Style of Processing (SOP; Childers et al., 1985), and categorizes the respondents’ learning styles in terms of a verbaliser – imager dimension (see also Riding & Cheema, 1991), a categorisation that stems from dual coding theory (Paivio, 1986). The instrument is devised to define a person’s “preference and propensity to engage in a verbal and/or visual modality of processing” (Childers et al., 1985, p 130), including both receiving instruction and processing information. The results from the SOP questionnaire place students in one of three learning style types: visual, mixed or verbal, where visual and verbal students have clear preferences for one or the other presentation format, whereas students with a mixed learning style do not (Ramsey & Deeter-Smelz, 2008; Heckler, Childers & Huston, 1993). SOP is in the present study considered synonymous with learning style, and “imager” is in this study considered synonymous with what Paivio (1971), Richardson (1977) and others have labelled “visualiser”.

Several previous studies have investigated the verbaliser - visualiser dimension of learning styles. Riding and Ashmore (1980) found that when presenting the same information verbally or pictorially to 11-year-old students, participants remembered more from the presentation matching their
own learning style. Similar results were found by Riding and Douglas (1993), when 15-16-year-old students were presented material on car braking systems, and by Smith and Woody (2000), showing that high-visual psychology students learned more from a multimodal class than their low-visual counterparts. Riding, Buckle, Thompson and Hagger (1989) found that visualisers responded faster to word pairs that required the use of mental pictures, and verbalisers to word pairs that needed verbal association. Similarly, Richardson (1977) showed that visualisers recalled high imagery material better than verbalisers. On the contrary, Massa and Mayer (2006) found that neither visual nor verbal learners performed better with instruction matching their own preference and Constantinidou and Baker (2002) found no support for an interaction between presentation format and visual versus verbal learning style. What they did find was that students receiving a visual presentation produced better free recall than students receiving purely verbal presentations. Heckler and colleagues (1993) suggest that visually oriented learners recall more of the visually presented material than verbally oriented learners, whereas the opposite relation was not supported. To conclude, support for the verbaliser - visualiser dimension of learning styles are at best inconsistent.

**Multimedia learning**

The hypothesis of visual and verbal instruction combined being superior to only verbal instruction (i.e., the multimedia instruction hypothesis) is also
derived from dual coding theory, suggesting that information is processed in two different channels, a verbal and a visual (Mayer, 2009; Paivio, 1986). Consequently, when words and pictures are presented simultaneously and in different modalities, that is, when words are presented auditorily rather than visually, both verbal and pictorial representations are being built and integrated (Mayer & Anderson 1992; Mayer, 2011; Mayer & Moreno, 1998; Moreno, Mayer, Spires, & Lester, 2001). Multimedia learning has shown to be a robust learning strategy in both lab and classroom settings as well as with different study materials, such as lightning formation, car break systems, animal behaviour and teaching principles (Harskamp, Mayer & Suhre, 2007; Johnson & Mayer, 2009; Jägerskog et al., 2015; Mayer, 2011; Mayer, Bove, Bryman, Mars & Tapangco, 1996; Mayer & Moreno, 1998; Moreno & Valdez, 2007). In the present study we compare two teaching strategies that both stem from dual coding theory, but where one is taking the individual differences approach (individual preference in terms of visual vs. verbal learning styles), and the other is a more general strategy that does not take the individual’s preference into account. On what should the teacher put his or her efforts?

**The present study**

In the present study we investigated the learning styles hypothesis in terms of the verbaliser-visualiser dimension, and the multimedia instruction hypothesis in psychology teaching. A key issue is whether teachers should
adapt their teaching according to students’ preferred learning style, or whether they instead should focus their efforts on a strategy that supposedly works well in general (multimedia learning) and independent of preference, in order to further improve student learning.

During study the students were presented the information either only verbally or with the aid of a visual illustration (i.e., visuoverbal presentation). As previously noted the SOP test divides the participants into three learning style types. The verbal learning style was thus matched with verbal learning only, and the visual and mixed learning styles were matched with visuoverbal learning. We did not include a purely visual presentation format because the study was conducted in an applied classroom setting, where purely visual instruction would not be contextually realistic. Support for the learning styles hypothesis would be seen either (i) if there would be a cross-over interaction where verbalisers gain more from a verbal presentation format than students with a mixed learning style and if students with a mixed learning style should benefit more from a visuoverbal presentation format than the verbalisers, and/or (ii) if the same pattern would occur when comparing visualisers with verbalisers. Given that visualisers prefer visual instruction, one could expect that also this group would outperform verbalisers in the visuoverbal condition, even though the condition is not purely visual, and more certainly that verbalisers would benefit more than visualisers from the verbal presentation format.
Method

Participants

The participants were 72 (37 female) upper secondary school students recruited from three different schools and five different national programs. They were in their second year with a mean age of 17.3 years ($SD = .56$). An additional two students participated, but were removed due to scoring zero on the learning test and/or not following the instructions.

Design

A 2 x 3 mixed design was used, where both presentation format (verbal vs. visuoverbal) and learning style (visual vs. mixed vs. verbal) were manipulated between subjects. Performance on the learning test was the dependent variable.

Materials

The to-be-learned material consisted of the Atkinson-Shiffrin memory model (Atkinson & Shiffrin, 1968), presented orally or both orally and visually, outlining the flow from sensory memory, to short-term memory and to long-term memory. The visual illustration included all different steps presented in the orally presented process and was, as the verbal presentation, derived from two high school textbooks in psychology (Fäldt, 2003; Smith, 1999). As in most introductory psychology textbooks the memory model was visually presented through boxes and arrows combining them.
The students were given a final learning test consisting of one open-ended recall question and five transfer questions, a test type similar to that used by Mayer and Moreno (1998). The recall question asked the students to write down everything they could remember from the presentation, whereas the transfer questions examined the students’ understanding of the content presented. See Jägerskog and colleagues (2015) for a complete list of questions.

The Swedish version of the *Style of Processing* questionnaire (SOP; Childers et al., 1985; Kalén et al., 2002) measured the students’ preferred way of receiving instruction and processing new information. The SOP questionnaire is a 22-item questionnaire assessing verbal-visual cognitive style, with a four-point Likert scale using “always true” to “always false”. The SOP questionnaire is based on Richardsson’s (1977) Verbaliser-Visualiser Questionnaire (VVQ), but is considered a more rigorous instrument, having higher external validity and internal consistency than the VVQ, which is why the SOP scale was being used (Childers et al., 1985; Ramsey & Deeterschmelz, 2008). The results from the SOP scale place participants in one of three learning styles groups: visual, mixed or verbal.

The participants also completed the *Modified Associative Learning* test (MAL; Lövdén, 2003), measuring the participants’ working memory and the *Mental Effort Tolerance Questionnaire* (METQ; Dornic, Ekehammar, & Laaksonen, 1991). In addition, the participants were asked about their age
and sex and received questions about their previous knowledge about the structure of the memory as well as their attitudes towards the material presented (i.e., how interesting it was, how difficult it was to learn, as well an estimation of how much of the presented material will be remembered after one week and 10 weeks respectively). The latter is not further discussed in this article.

**Procedure**

The participants were tested in 12 already existing classes, with an average size of six students (range: 4-10). First, brief instructions about the session were given and the students were asked to fill the questions about their age and sex, as well as questions about their previous knowledge about the structure of the memory. Second, the verbal presentation was being held. In six of the classes, randomly assigned to this condition, the presenter simultaneously drew a visual illustration on the white board. The presentation was six minutes long and was held in the classroom by the same presenter in all classes (the first author). The participants did not interact during this part of the procedure and transfer questions were not explicitly discussed in the oral presentation. Third, the participants completed the METQ questionnaire. Fourth, all participants were given 10 minutes to restudy the material presented by reading the written manuscript of the verbal presentation. Fifth, the participants completed the questionnaire concerning their attitudes to-

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1 For the purpose of another research question this step was included in the procedure. Results are reported in Jägerskog, Jönsson, Selander and Jonsson (2015).
wards the material presented as well as filled in the SOP questionnaire. Finally, the students were asked to answer the recall question (8 minutes) and the five transfer questions (3 minutes each). The answers were written by hand and each question was presented and answered on a separate sheet. At a later occasion the students were also asked to complete the MAL test.

**Scoring**

A subsample (10%) of the learning tests was scored by two independent raters, both blind to which group the individual participant belonged to. Since the inter-rater reliability was very high ($r = .99$ for recall and $r = .94$ for transfer), only one of the raters (the first author) scored the remaining data. On the recall question, one point was given for each of the main ideas presented in the verbal presentation, such as the long-term memory, the short-term memory, the sensory memory, the need for retrieval, the use of repetition, etc. Scores were given for answers worded differently from the verbal presentation, but not for vague answers. The five transfer questions consisted of a total of 19 acceptable answers and dealt with issues such as why one forgets, why repetition is good and possible problems with an injured short-term memory. One point was given for each acceptable answer. The scores on the different transfer questions were summed and computed into a proportion, as were the recall scores. A mean proportion of the scores from the two question types was calculated in order to analyse recall and transfer combined.
Results

Background analysis

In order to investigate if the classes differed in terms of background variables, self-rated previous knowledge, the METQ score and the MAL score were entered as the dependent variable in three separate ANOVAs with class as the independent variable. The participants’ self-rated previous knowledge about the to-be-learnt material was limited and did not differ significantly between the classes ($p = .96$). Neither did the tolerance for mental effort, as measured with the METQ questionnaire ($p = .20$), or working memory, as measured with the MAL test ($p = .22$).

Learning outcome

To investigate whether the data provides support for the multimedia instruction hypothesis and the learning styles hypothesis in terms of the verbaliser – visualiser dimension, learning test performance was entered into a learning style (visual vs. mixed vs. verbal) x presentation format (verbal vs. visuoverbal) mixed factorial ANOVA. Because learning is often seen as a combination of recall and transfer (Mayer, 2009) the study included both measures. However, as we had no particular interest in this variable in the present study, a total learning score based on both these measures was used. Three interesting results emerged from the ANOVA:
Firstly, the multimedia instruction hypothesis was supported in a significant main effect of presentation format $F(1, 71) = 27.37, \text{MSE} = .55, p < .001$. As shown in Figure 1, and as previously presented in Jägerskog and colleagues (2015), students who received visuoverbal instruction scored significantly higher on the learning test compared to students who only received a verbal presentation ($d = 1.12$). In terms of effect sizes, and as shown in Figure 3, visuoverbal learning was better than verbal learning independently of learning style (visual, $d = 2.63$; mixed, $d = 0.99$; verbal, $d = 0.63$). However, independent $t$-tests showed that this difference was statistically significant for the visual ($p < .001$) and mixed ($p = .027$) learning style groups, but not for students with a verbal learning style ($p = .22$).

**Figure 1.** Mean proportion correct answers for the verbal and visuoverbal presentation formats respectively. Error bars represent the standard errors.
Secondly, a significant main effect of learning style was found $F(2, 71) = 5.79$, $MSE = .12$, $p = .005$. As shown in Figure 2 and with Tukey posthoc tests, students with a visual ($p = .01$) or a mixed ($p = .01$) learning style performed generally better on the learning test compared to students with a verbal learning style. Note that this is not a test of the learning style hypothesis, as that hypothesis refers to the match between preferred and received way of learning. Instead, the main effect shows that those who have a mixed or visual learning style preference perform better independent of presentation format.

*Figure 2.* Mean proportion correct answers for all participants across the different learning style groups. Error bars represent the standard errors.
Thirdly, we inspected the results for possible support for the learning styles hypothesis, that is, whether there was a reliable learning style by presentation format interaction. The data analysis showed a marginally significant interaction between learning style and presentation format, $F(2, 71) = 3.12, MSE = .06, p = .051$. As shown in Figure 3, this interaction is driven by participants with a visual learning style benefitting more from a visuoverbal presentation format than participants with a mixed or verbal learning style. It is evident from Figure 3 that when comparing the mixed with the verbal learning style groups as a function of presentation format, no interaction is present. Further, when instead comparing the visual with the verbal learning styles groups as a function of presentation format, the interaction is not in the form of a crossover interaction. This means that the learning styles hypothesis did not render support in the present study.

![Figure 3](image.png)

*Figure 3.* Mean proportion correct answers across the different learning style groups for the verbal and visuoverbal presentation formats respectively. Error bars represent the standard errors.
General Discussion

We investigated whether teachers, in order to improve student learning, should adapt their teaching in accordance with students’ preferred learning style (verbaliser - visualiser), or on a strategy that may instead work well for most students and independent of preference (multimedia learning). Consistent with much previous research (e.g., Constantinidou & Baker, 2002; Massa & Mayer, 2006; Mayer, 2010; Mayer & Moreno, 1998; Moreno et al., 2001; Paivio, 1986) a visuoverbal presentation resulted in better learning than a verbal presentation only. Also, students with a visual or mixed learning style outperformed students with a verbal learning style on the learning test in general. However, the present data did not support the learning styles hypothesis.

The multimedia instruction hypothesis was supported in that visuoverbal presentation led to better learning than only verbal presentation (see Jägerskog et al, 2005, for a further discussion of this). Noteworthy, in terms of effect sizes the multimedia instruction hypothesis was replicated independently of preferred learning style, which renders strong support for the hypothesis in terms of its generalizability. The fact that there was no statistically significant effect of multimedia learning for students with a verbal learning style only could be due to low power.
We found no support for the learning styles hypothesis in terms of the verbaliser – visualiser dimension, as there was no crossover interaction between learning style (visual or mixed vs. verbal) and presentation format (see Pashler et al., 2008). However, similar to Heckler and colleagues (1993), we found that visualisers benefited more from the switch from verbal to visuoverbal presentation than verbalisers. Although a partial result in line with the idea that learning styles may matter (i.e., only for the visualisers), the absence of the required crossover interaction makes this finding less convincing. The visuoverbal presentation format includes both verbal and visual components and could be considered to primarily relate to the mixed learning style rather than the visual, but no matter how it is considered conclusions are the same. There is no crossover interaction and the verbal presentation format as well as the verbal learning style seems to result in the lowest learning outcome in general. Hence, despite the popularity of learning styles, and in line with other studies (see Pashler et al., 2008 for a review), the present study suggests that students’ preferred individual learning styles should not be a focal aspect for teachers when planning their teaching.

Most interestingly, students with a visual or mixed learning style outperformed students with a verbal learning style on the learning test in general; the only exception being that visualisers performed at the same level as verbalisers in the verbal condition. The results are similar to those of Massa and Mayer (2006). Given that learning style is considered a preference rather
than an ability (e.g., Childers, 1985; Pashler et al., 2008) a question arises if students can be guided towards a visual preference and thereby increase their learning. Childers and colleagues (1985) suggested that the style of processing is “a preference and propensity to engage in a verbal and/or visual modality of processing” (p. 130). This, they suggested, includes both attention and elaboration stages of information processing. An individual with a visual learning style may be prone to use mental imagery more than individuals with a verbal learning style and therefore to a greater extent use the working memory to form visual mental representations of cues also when presented with verbal information only (Heckler et al., 1993; Riding et al., 1989). This could be termed as an “internal multimedia effect” and an explanation to why students with a visual or mixed learning style seem to learn more than verbal processors from the same material. If this is the case, classroom teaching should encourage and create possibilities for students to develop the ability to create visual mental representations. In line with this, Price (2004, p. 686) suggests that “visual representations can facilitate the development of students’ own mental models, enabling them to visualise abstract concepts”.

The present study has several implications. Although individual differences are important to take into account when teaching (e.g., Clark & Feldon, 2010; McNamara et al., 1996; Pashler et al., 2008), adapting classroom teaching to individual differences in terms of preferred learning styles
may not be the most efficient way to help students improve their learning. Also, assuming that students have a certain learning style may risk that focus is given to an individual’s fairly static learning style rather than the possibility to develop flexibility in modes of processing (Curry, 1990; Kirby, Moore & Schofield, 1988). Possibly the idea behind learning style might be more relevant for subjects and subject content than for individuals, in that different subjects, tasks and subject content need different instructional modes (Constantinidou & Baker, 2002; Kollöffel, 2012; Pashler et al., 2008; Price, 2004; Riding, Grimley, Dahraei & Banner, 2003; Willingham, 2006). More research is needed to clarify those different aspects related to the learning style concept.

Instead, because the use of visual illustrations seem to have a beneficial effect on learning for most students independent of their preferred learning style, the present data indicates that this mode of instruction ought to be used in psychology classroom teaching for the age group and content tested. Interestingly, the results also suggest that visualisers and students with a mixed learning style learn more than verbalisers from the same material, which could imply that it is worthwhile to help students develop a preference for visual or multimodal aspects of information processing.

Because this study only investigates psychology learning in emerging adulthood future studies should focus on for instance younger participants, different subject content and children with diagnosed learning difficulties in
order to address the full potential of these findings for teaching. We concur with some previous researchers in that more research is needed about learning styles before implementing it in educational practice (Cassidy, 2004; Curry, 1990; Pashler et al., 2008). In the meantime, this study suggests that the use of visual illustrations ought to be encouraged in psychology teaching for all upper secondary students, independently of preferred learning style.

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