Department of Psychology and Logopedics
Faculty of Medicine
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FROM QUALIA TO QUALITY RATINGS

SUBJECTIVE EXPERIENCE, CONSCIOUS THOUGHT AND HOW DECISIONS ARE EXPLAINED

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Doctoral Programme of Psychology, Learning and Communication (PsyCo)

DOCTORAL DISSERTATION

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ABSTRACT

Academic psychology has traditionally considered subjective explanations for judgments and decisions unreliable or even fabricated. Additionally, explanations have been shown to interfere with judgment and decision making processes, which can degrade the quality of choices. These phenomena have been attributed to processes that cannot be verbalized, either because of the lack of vocabulary or conscious access to these processes. This is assumed to shift the processing from the non-verbal or non-conscious mode into a more verbal and conscious mode, leading to either fabrication or interference. The problem affects particularly the judgments and decisions that are based on *subjective experience*.

This dissertation examines these effects in the context of high image quality by assuming that subjective experience is a highly relevant intermediate processing stage in perceptual decision making, whereas subjective explanations reflect the contents of socially oriented *conscious thought,* which originates from the metacognitive understanding related to the judgment and decision-making processes. When these different forms of conscious mental content are dissociated due to social pressure or lack of conceptual knowledge about the perceptual features, interference or fabrication can occur.

This dissertation presents the ideas underlying the Interpretation-Based Quality (IBQ) method, which emphasizes the special nature of subjective experience (or phenomenal consciousness) in judgments and decisions: Every individual has his or her own subjective point of view, from which the world is interpreted. These interpretations underlie personal and subjective experience. In the context of preferential judgment and decision making, the differences between individuals, arising from different ways of experiencing the world, are easily regarded as measurement error. The IBQ method approaches these differences by asking research participants to explain their decisions in their own words. These explanations have been further analyzed qualitatively in order to find the relevant subjective dimensions on which decisions are based.

As subjective explanations are used as data, the use of the IBQ method must respond to claims concerning unreliability, fabrication and interference. Therefore, four studies were conducted to test these claims in the evaluation of high image quality. As explaining has been found to shift processing into a more conscious mode, these studies can also inform about the role of conscious thought in perceptual judgments and decisions.

The general finding of this research was that conscious thought, evoked by the requirement to explain judgments, can also enhance the decision maker's performance in cases that require tradeoffs, effortful information search and consistency over several decisions. This is typical for the context of high image quality evaluation, where the differences between stimuli are small and

multidimensional. The results suggest that, generally, when conscious thought and subjective experience work in concert, subjective explanations can provide highly useful qualitative data about the dimensions of subjective experience that are relevant in judgments and decisions. These dimensions are dependent on personal and contextual factors and cannot be predicted from physical data alone.

The results support the recent findings and theoretical contributions about the relations between decision making and consciousness. They emphasize the role of phenomenal consciousness as a multi-dimensional space where information about voluntary actions is presented. The information integration processes, however, are usually automatic and non-conscious. The importance of conscious thought in decision making appears to be its ability to bring relevant information into consciousness by means of voluntary attention. This happens particularly in conflicts and when the decisions are novel. In these situations conscious thought and an analytic approach is activated automatically. This mechanism derives from metacognitive understanding, which is learned gradually in similar judgment and decision-making situations.

TIIVISTELMÄ

Akateemisen psykologian piirissä on perinteisesti suhtauduttu skeptisesti selityksille, joita ihmiset antavat päätöksilleen: Niitä on pidetty – ei pelkästään epäluotettavina – vaan suorastaan tekaistuina. Lisäksi päätösten selittämisen on todettu vaikuttavan itse päätöksentekoprosessiin, toisinaan häiritsevästi. Näiden ilmiöiden on oletettu johtuvan siitä, että päätöksentekoprosesseja on vaikea sanallistaa, joko käsitteellisen tiedon puutteen vuoksi, tai koska yksilöllä ei ole pääsyä prosesseihin, jotka ovat tiedostamattomia. Alkuperäisen prosessin sanallistamisen vaikeus saattaa muuttaa prosesseja helpommin sanallistettavaan muotoon, jolloin yhteys alkuperäiseen päätöksentekoprosessiin tai jopa aitoihin mieltymyksiin katoaa. Tästä seurauksena voi olla tekaistu selitys, joka ei kerro alkuperäisestä prosessista, tai jollain tavalla muuttunut päätös prosessin muutoksen tuloksena.

Näiden ilmiöiden on oletettu koskevan erityisesti päätöksiä, joita tehdään *subjektiivisen kokemuksen* perusteella. Subjektiivinen kokemus viittaa fenomenaaliseen tietoisuuteen, eli siihen miten koetaan kipu, punaisen näkeminen tai vaikkapa viha, erotuksena tietoisesta ajattelusta, jossa näitä kokemuksia voidaan reflektoida ja esimerkiksi liittää aikaisempiin kokemuksiin. Tämä väitöskirja tarkastelee kyseisiä ilmiöitä kuvanlaadun arvioinnin kontekstissa, olettaen että subjektiivisen kokemus on olennainen välivaihe matalan tason havaintoprosessien ja varsinaisen päätöksen välillä. Selitykset päätöksille taas heijastelevat tietoista ajattelua, jonka ajatellaan olevan sosiaalista todellisuutta heijasteleva korkeamman asteen tietoisuuden muoto. Tietoinen ajattelu siis pohjaa päätöstilanteiden metakognitiiviseen ymmärtämiseen. Jos tietoisen ajattelun yhteys subjektiiviseen kokemukseen ei toimi kunnolla, esimerkiksi sosiaalisen paineen vuoksi, selittämisen aiheuttama prosessin muutos voi häiritä päätöksiä tai johtaa tekaistuihin selityksiin.

Väitöskirjassa esitellään *tulkintaan perustuva laatu* -lähestymistapa *(Interpretation-Based Quality,* lyh. IBQ*)*, joka korostaa subjektiivisen kokemuksen (eli fenomenaalisen tietoisuuden) erityistä luonnetta päätöksenteossa: subjektiivinen kokemus syntyy aina yksilöllisestä näkökulmasta, jonka kautta maailmaa tulkitaan. Jos nämä tulkinnat eivät ole tutkijan tiedossa, yksilöiden väliset erot tulkitaan helposti mittausvirheeksi. IBQ lähestyy näitä eroja pyytämällä koehenkilöitä kuvaamaan perusteluja tekemilleen päätöksille omin sanoin. Perustelut analysoidaan laadullisesti, jotta pystytään kuvaamaan koehenkilöiden päätöksenteon kannalta olennaiset ulottuvuudet (eli päätöksentekoavaruus).

Koska tutkimusaineistona käytetään subjektiivisia selityksiä päätöksille, on IBQ-menetelmän vastattava kyseisiin tutkimusmenetelmiin liittyvään kritiikkiin, koskien perustelujen luotettavuutta ja niiden vaikutusta alkuperäiseen päätöksentekoprosessiin. Tämän vuoksi suoritettiin neljä

tutkimusta, joissa tarkasteltiin ko. väitteisiin liittyviä tutkimuskysymyksiä. Tutkimusten konteksti oli kuvanlaadun arviointi. Koska päätösten selittämisen on todettu muuttavan ajatteluprosessia tietoisemmaksi, tutkimusten avulla on mahdollista myös ymmärtää tietoisen ajattelun merkitystä aistinvaraisissa päätöksissä.

Tutkimusten perusteella voidaan sanoa, että päätösten perusteleminen ja siihen liittyvä tietoinen ajattelu voi myös parantaa päätöksentekijän suoriutumista, kun päätös vaatii kompromisseja vaihtoehtojen eri ominaisuuksien välillä, tahdonalaista tiedonhakua tai yhdenmukaisuutta eri päätösten välillä. Nämä kaikki ovat tyypillisiä korkean tason kuvanlaadulle, jossa erot ärsykkeiden välillä ovat pieniä ja moniulotteisia. Tulokset osoittavat, että kun tietoinen ajattelu ja subjektiivinen kokemus ovat sopusoinnussa, subjektiiviset perustelut päätöksille voivat tuottaa hyödyllistä tietoa olennaisista päätöksentekoulottuvuuksista. Nämä ulottuvuudet ovat riippuvaisia yksilö- ja kontekstitekijöistä eikä niitä ole mahdollista ennustaa fysikaalisesta informaatiosta.

Tulokset tukevat viimeaikaisia tutkimustuloksia ja teorioita tietoisuuden ja päätöksenteon suhteesta. Nämä korostavat fenomenaalisen tietoisuuden merkitystä paikkana, jossa päätöksenteon kannalta olennainen tieto esitetään. Tiedon integrointi päätökseksi kuitenkin tapahtuu useimmiten tiedostamatta automaattisesti. Tietoisen ajattelun merkitys päätöksenteossa näyttäisi siis olevan tahdonalaisen tarkkaavaisuuden avulla tuoda päätöksen kannalta olennainen informaatio tietoisuuteen. Näin todennäköisesti tapahtuu erityisesti konflikteissa ja kun päätös on yksilölle uusi. Näissä tilanteissa tietoinen ajattelu ja analyyttinen lähestymistapa useimmiten aktivoituvat automaattisesti.

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CONTENTS

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following publications:

I Radun, J., Leisti, T., Virtanen, T., Häkkinen, J., Vuori, T., & Nyman, G. (2010). Evaluating the multivariate visual quality performance of image-processing components. *ACM Transactions on Applied Perception*, *7*, 16.

II Leisti, T., Radun, J., Virtanen, T., Nyman, G., & Häkkinen, J. (2014). Concurrent explanations can enhance visual decision making. *Acta Psychologica*, *145*, 65-74.

III Leisti, T., & Häkkinen, J. (2016). The effect of introspection on judgment and decision making is dependent on the quality of conscious thinking. *Consciousness and Cognition*, *42*, 340-351.

IV Leisti, T., & Häkkinen, J. (2018). Learning to decide with and without reasoning: How task experience affects attribute weighting and preference stability. *Journal of Behavioral Decision Making, 31*, 367–379.

The publications are referred to in the text by their Roman numerals. Study I has been published previously as part of Jenni Radun's (2016) doctoral dissertation.

ABBREVIATIONS

ANOVA	analysis of variance
AUR	area under ROC
CA	correspondence analysis
IBQ	interpretation-based quality
IQ	image quality
ISP	image signal processor
JDM	judgment and decision making
MOS	mean opinion score
ROC	receiver operating characteristics
S-R	stimulus-response
WADD	weighted additive

1 INTRODUCTION

Giving reasons for our decisions would appear to be a completely normal everyday skill. When someone is unable to do it, it is usually considered a sign of irrationality (Kozuch & Nichols, 2011). As we are often required to make choices that involve others, both as individuals or in groups, the ability to make one's actions understandable and accepted bears an important social function (Baumeister, Clark, Kim, & Lau, 2017; Baumeister & Masicampo, 2010; Mercier & Sperber, 2011). Relevant arguments can be taken as a sign that one has considered all the relevant aspects of a decision and that the decision maker is trustworthy and able to take responsibility for those decisions; therefore requiring explanations for decisions can be seen as a form of accountability (Lerner & Tetlock, 1999). Keeping these aspects in mind, it easy to understand why folk psychology places so much weight on thorough deliberation and regards rational reasoning processes as transparent to introspection (Kozuch & Nichols, 2011).

How well can we understand the decisions of individuals just by asking them to offer their subjective explanations? Although this is something that we often do, and our everyday experience suggests that it is a valid practice, attitudes in academic psychology have been skeptical about the scientific value of this kind of data from the early 1900s, when behaviorism aimed to get rid of all data that it considered subjective (D. A. Lieberman, 1979; Watson, 1913). Even after the behaviorist era, experimental research remained focused on subjective phenomena as responses to stimuli, not on how subjective mental contents mediate behavior, practically following the behaviorist tradition (D. A. Lieberman, 1979).

The emerging cognitive science declared (conscious) thoughts to be objects of investigation in the seventies, and the experimenters probed research participants' thoughts by asking them to think aloud (e.g. Payne, 1976; Simon & Newell, 1972). This, however, did not change the attitudes of psychologists in general, at least in matters of judgment and decision making (Nisbett & Wilson, 1977). The proponents of think-aloud methods wanted to make a clear distinction between thinking aloud, which was considered to be a somewhat objective description of the thought process, and subjective explanations, which were assumed to be invalid subjective interpretations about the mental processes and prone to omissions (Ericsson & Simon, 1980).

Certain empirical findings further supported the skeptics: Nisbett and Wilson (1977), for instance, showed that people are unable to report all factors that affect their choices, and they appear to explain their choices by relying on a culturally shared stockpile of plausible reasons. Furthermore, it was later shown that individuals easily fabricate reasons for their actions: this was first found among patients who had gone through a split-brain operation (Gazzaniga, 1989), and then with normal healthy adults (Johansson, Hall, Sikström, & Olsson, 2005). This fabrication tends to occur involuntarily and without awareness (Gazzaniga, 1989). In addition to fabrication, requiring individuals to explain their judgments sometimes appears to have a distracting effect (Wilson & Schooler, 1991), contrary to the view emphasizing justification as a form of accountability.

The hypothesis that additional self-reflection has a detrimental effect on judgments contradicts the usual view of reason and conscious thinking as the source of rationality. Irrationality has traditionally been attributed to emotions or Freudian subconscious impulses, for instance. All these findings, suggesting that people are limited in their ability to reflect on their judgment and decision making (JDM) processes, have attracted much attention, as can be seen by looking at citation counts. The reason for this may be the fact that the traditional view of humans as socially responsible agents requires them to be aware of what they are doing (Doris, 2018; Frith, 2012).

This dissertation concerns the role of the explanations given to judgments and decisions that are based on *subjective experience*. Skepticism that has been associated with people's ability to introspect the reasons for their judgments has been most prominent in such tasks, as they require transforming subjective and private, non-verbal experiences into words (Ericsson & Simon, 1980; Wilson, Dunn, Kraft, & Lisle, 1989; Wilson & Schooler, 1991). Furthermore, these subjective experiences are often assumed to be based on processes that are not within the reach of conscious access (Nisbett & Wilson, 1977), increasing the probability that individuals have a tendency to theorize the reasons for their actions.

Decisions based on subjective experience are not marginal; on the contrary: many prominent authors suggest that most decisions we make are in fact based on intuitive impressions (Kahneman, 2003), emotions (Bechara & Damasio, 2005), or percepts about the outside world or our bodily states (Morsella, Godwin, Jantz, Krieger, & Gazzaley, 2016). Decisions that are based on *conscious thought*, that is, deliberative manipulation of information in working memory (Evans & Stanovich, 2013), should then represent a tiny minority of all decisions (Bargh & Chartrand, 1999). Therefore, this research problem concerns a wide variety of judgment and decision tasks that people face in their daily lives and which they may be asked to explain.

Despite the results questioning the ability to introspect reasons for their behaviors, people have not stopped asking for explanations for judgments and decisions, even in academic environments. This dissertation therefore approaches subjective explanations both as a scientific method, which is supposed to give insights into an individual's basis of decisions, as well as social behavior, which justifies these decisions to others. These aspects can sometimes be in contradiction, as will later be discussed. The purpose of the present approach is to take a new look at the explanations: instead of relying on the conscious-reportable vs. non-conscious-non-reportable dichotomy, it is based on the assumption of the interaction between conscious and non-conscious processes.

From these premises, three central aspects arise: 1) subjective experience is a relevant part of the interactive causal chain between the objective world and decisions; 2) the validity and the reliability of the data based on explanations is dependent on the experimental design and the familiarity of the task to the individual; and 3) the effect of explaining on the performance in JDM tasks is variable and dependent on the task properties, instructions and abilities of the individual. This dissertation investigates these problems in the context of visual quality.

1.1 CONSCIOUSNESS

Understanding how the explanations for decisions are generated requires some knowledge about two forms of conscious mental content, *subjective experience* and *conscious thought*.[1] Explanations reflect conscious thoughts (Baumeister et. al 2010); the judgments and the choices that are in focus in this research, however, are based on the information present in subjective experience. Dissociation between these mental contents appears to be one of the main reasons for the counter-intuitive results that have been found concerning people's ability to introspect reasons for their behaviors (Reber, Winkielman, & Schwarz, 1998; Winkielman & Schooler, 2011). Therefore the next sections concentrate on describing their role and interactions in JDM.

1.1.1 SUBJECTIVE EXPERIENCE

Subjective experience, or *phenomenal consciousness*, is usually regarded as the more primitive, non-reflective form of consciousness. When discussing its contents, or *qualia*, we refer to what it is like to be in a certain mental state (Nagel, 1974), such as seeing red, or feeling anger or pain, etc. In other words, in phenomenal consciousness we *experience* red, pain or emotions. These represent private, first-person knowledge, and there is no way to measure subjective experience objectively (Nagel, 1974): for instance, we may study a bat's brain extensively when it uses echolocation to find prey but this objective knowledge does not reveal how the bat experiences its environment. In other words, objective third-person knowledge never fully captures the first-person point of view of subjective experience. When humans are concerned, the only way to access this experiential knowledge is by asking an individual to report it. Even then we are restricted by language (or any other communication method) and how observers are able to describe their experiences and how the listener is able to understand these descriptions. These problems relating to

[1] The division between these two is not absolute, rather the purpose is to use concepts concerning consciousness that have been relevant in empirical literature.

the reliance on first-person knowledge, rather than (neutral) third-person knowledge, have since Watson (1913) been the main argument when scientific inquiry towards subjective experience has been opposed.

Nevertheless, many scientists nowadays assume that subjective experience plays a crucial role in the survival of humans and animals, such as mammals and birds, with complex cognitions. According to the contemporary view, information processing of the brain is distributed to a massive parallel set of specialized processors, or modules (Baars, 2005; Dehaene, Lau, & Kouider, 2017; Fodor, 1983; Gazzaniga, 1989; Morsella et al., 2016; Zeki & Bartels, 1999). For example, information from the eye is directed to numerous neural units that process different visual features, such as line orientations, movement and color. This feature information is further utilized by processors that guide body movements and analyze the identities of the objects in the visual scene (Goodale & Milner, 1992; Kravitz, Saleem, Baker, Ungerleider, & Mishkin, 2013; Prinz, 2000). A fundamental question is how is coherent action possible when information processing is fragmented to different locations of the brain and, in particular, when the results of these processors are in conflict with each other in a complex human brain?

The solution to this problem would introduce an intermediate phase of processing between sensation and action, where the information relevant to current needs is selected so that coherent behavior becomes possible. A converging consensus among scientists suggests that this is the function of consciousness (Baars, 2005; Dennett, 2001; Morsella, 2005; Morsella et al., 2016). In other words, phenomenal consciousness is, as Dehaene et al. (2006) call it, a *global neuronal workspace*, where modules distribute the results of their processes and from where this information is available as input to other modules, offering a coordinated information exchange between different parts of the brain (Baars, 2005; Dehaene et al., 2006; Dennett, 2001). It is not a specialized center or area in the brain: there is no evidence that consciousness would be a specific property of any neural processor, because all parts of the brain appear to be involved in non-conscious processing; rather it is the global information distribution that creates consciousness (Dehaene et al., 2006; Zeki & Bartels, 1999). Global distribution of visual information has been suggested to be dependent on recurrent processing, that is, a reciprocal relationship between extrastriate visual cortices and prefrontal cortices, mediated by long-range cortico-cortical feedforward and feedback projections (Koch & Tsuchiya, 2006; Lau & Rosenthal, 2011).

Not all information from the numerous modules are, nor can be, broadcasted to the whole brain. Phenomena such as backward masking, binocular rivalry and inattentional blindness show that visual consciousness has a limited capacity (Baars, 2005; Cohen, Dennett, & Kanwisher, 2016) that is often contrary to people's intuitions. For example, in the famous study where research participants are asked to count the number of passes in a basketball game, most of them are unaware of a man in a gorilla suit crossing the field of play (Simons & Chabris, 2000). Hence, the task-specific focus of attention appears to block task-irrelevant visual information from becoming conscious. Attention thus regulates the access of the information to the consciousness: it amplifies the local neural activation and distributes it to other parts of the brain, creating mutual amplification loops (Baars, 2005; Dehaene et al., 2006). In this way, coordinated information exchange in the brain is dependent on attention.

When attention blocks visual information from becoming conscious, the activation does not spread globally from the visual cortex to other areas of the brain (Baars, 2005; Dehaene et al., 2006). Some weak activation still occurs outside the visual cortex, though: despite the absence of top-down amplification, this *preconscious* processing can guide rapid, transient and stereotyped behaviors that are based on feed-forward information (Crick & Koch, 2003). Many of our everyday behaviors are based on such automatic behaviors, so our limited attentional capacity is available for other duties (Koch & Tsuchiya, 2006). When attention is directed towards the object or an event, but the local neuronal activation in the visual cortex is too weak to become globally distributed even with top-down activation, for example due to short presentation times, the object can still affect behavior *subliminally* for a short time, but it does not become conscious (Dehaene et al., 2006). Top-down (selective) attention is not, therefore, synonymous with consciousness (Dehaene, Charles, King, & Marti, 2014; Koch & Tsuchiya, 2006).

Subliminal, non-conscious activation can spread widely in the brain and can initiate several complex processes. Only conscious information, however, can be routed strategically into and through several stages in multi-stage processing. Subliminally perceived information, therefore, has no role in tasks that require using perceptual information as the input to subsequent processes (Dehaene et al., 2014). Additionally, only conscious representations can be used in the strategic guidance of attention (Naccache, 2005), or can determine voluntary actions (Morsella et al., 2016). Without both attention and adequate activation, neural activity remains unconscious (Dehaene et al., 2006) [2].

Accumulating evidence suggests that subjective richness of visual experience is based on backwards connections and recurrent processing: First, bottom-up connections offer a gist of the visible scene, then top-down amplification enables the examination of details, resulting in recurrent

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[2] There are also other ways to define conscious states. Ned Block (1995), for instance, suggests a division between phenomenal consciousness and *access consciousness,* the contents of which are available for reporting and symbolic cognitive functions in general. The contents of phenomenal consciousness become access conscious, when attention is directed to them. This definition of phenomenal consciousness is empirically problematic, as it is impossible to gather knowledge about phenomena that are, by definition, unreportable. Otherwise, a phenomenal consciousness outside of access consciousness appears to be an illusion (Cohen & Dennett, 2011): for example, although we have illusory experience that the whole visual scene has colors, humans are only able to extract color information through the fovea of the eye.

processing and thus conscious experience (Crick & Koch, 2003; Hochstein & Ahissar, 2002; Kravitz et al., 2013; Lamme, 2006).[3] The feeling that consciousness itself is a rich and static representation of the environment in the brain is therefore somewhat illusory or virtual: by focusing and moving our eyes, we can bring detailed visual information to our experience, but this information exists in consciousness only as long as attention is guided to it (Blackmore, Brelstaff, Nelson, & Trościanko, 1995). Otherwise we rely on simple gist, which summarizes the statistical properties of the environment (Cohen et al., 2016; Koch & Tsuchiya, 2006). Attention guides information acquisition that is active and purposeful; it follows the current activities and thoughts of the observer (Cohen et al., 2016; O'Regan & Noë, 2001).

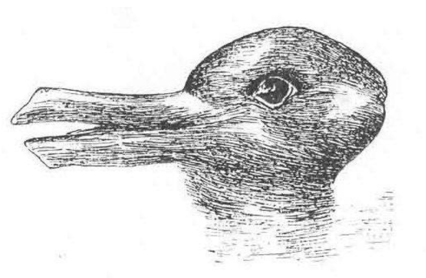

Figure 1 An ambiguous figure. The figure can be seen as either a rabbit or as a duck but never both at the same time.

The information that enters consciousness is suggested to be supra-modular (Morsella, 2005) – it represents information that already integrates results from several individual modules, also over different modalities. For example, we do not perceive separately the sounds and the movements of lips when someone talks (McGurk & MacDonald, 1976), instead these two elements form a meaningful whole to the listener. Perception is thus automatically interpreted. Similarly, we can see only one interpretation at a time in ambiguous figures (Figure 1). We can change between interpretations but we cannot see a rabbit and a duck at the same time. This ensures that our perceptions stay coherent (Seth, Baars, & Edelman, 2005), which is based on mutual communication between different areas of the brain (Zeki & Bartels, 1999). Hence, it has been suggested that consciousness consists of 'mid-level' representations; the high-level contextual representations, or interpretations, guide attention and make experiences conscious but they themselves remain unconscious; also the low-level processing of visual features is non-conscious

[3] It is worth noting that although Lamme (2006), Crick and Koch (2003) and Dehaene et al. (2006) agree on the recurrent processing as a definite requirement for conscious experience, they differ in other respects. Lamme (2006), in addition, even distinguishes between reportability and consciousness, thus diverging from other authors and this dissertation where operationalization of consciousness is concerned.

(Prinz, 2000). As a demonstration of the way experiences are shaped by contexts we not may not be aware (Baars, Ramsoy, & Laureys, 2003), the duck-rabbit is more often seen as a rabbit near Easter (Brugger & Brugger, 1993).

In the case of image quality, which is the context of this thesis, interpretation of the visual scene determines how different visual features are experienced by the observer. For example, naïve observers may not perceive a certain luminance level and color combination as separate sensations, but interpret the image content and perceive the scene as sunny or overcast in relation to the content of the image (see Figure 2). The already-interpreted nature of subjective experience is of course central to the ability to behave in a coordinated manner; if our phenomenal consciousness would consist of fragmented information with contradictory data only, without clear meanings, everyday behavior would be impossible. The role of subjective experience is therefore to guide coherent behavior by offering unambiguous perceptual experience as a basis for voluntary decisions between different actions (Jack & Shallice, 2001; Morsella et al., 2016).

Figure 2 How interpretation of the scene affects experience. Figure b has reduced brightness and bluish tint. It is seen as rainy, due to the interpretation of the image context.

1.1.2 CONSCIOUS THOUGHT

In addition to sensory experiences and feelings at the immediate moment, humans have more sophisticated conscious mental states, namely conscious thoughts,[4] which can reflect current experiences, distance oneself from current perceptions, reason, create a sense of self and infer causalities between instances (Baumeister & Masicampo, 2010; Crick & Koch, 2003; Schooler, 2002). These thoughts enable active information maintenance and manipulation in the working memory, flexible combination of information,

[4] There are also other naming conventions for these different levels of awareness, such as consciousness and meta-consciousness (Schooler, 2002) or primary consciousness and higher order consciousness (Crick & Koch, 2003). The dichotomy is nevertheless between the ‘pure’ subjective experiences and more reflective mental states that can distance one from current perceptions and can evaluate, for instance, the consequences of different actions in the future.

following rules in a precise and selective manner, and deliberation using mental simulations of the costs and benefits of the actions (Baumeister & Masicampo, 2010; Evans & Stanovich, 2013; Hofmann & Wilson, 2010). When the contents of phenomenal consciousness refer, say, to the pure experience of 'redness,' conscious thinking may consist of reflective thought about 'redness,' for instance, "I am seeing red" or "the redness in his face in this image makes him look sick." That someone appears sick in an image is also a subjective experience; the reflective thought is the mental process that relates sickness to the redness in this case, and assumes a causal relation between these experiences (Baumeister & Masicampo, 2010). In some other case, e.g. without the presence of a human face, the image may be experienced as more reddish, warm and more atmospheric. Conscious thought in this case may create a causal link between redness, warmth and a better atmosphere. Narratives link experiences together, and they can be used for understanding similar events in the future or the past (Baumeister & Masicampo, 2010). Without them our conscious self would lack order and coherence (Gallagher, 2000; Hofmann & Wilson, 2010; Turk, Heatherton, Neil Macrae, Kelley, & Gazzaniga, 2003). As the topic of this dissertation concerns explaining one's judgments and decisions, this kind of causal reasoning is central to my theme.

Whereas phenomenal consciousness integrates sensory inputs and enables an animal to act coherently in its physical environment, conscious human thought integrates phenomenal consciousness with cultural and social demands and coordinates behavior in the social environment (Baumeister & Masicampo, 2010; Mercier & Sperber, 2011). With the ability to think consciously about different alternatives, a human individual can simulate the consequences of different actions, for example the possible reactions of other people. This ability enables understanding of others, understanding of oneself and making one understandable to others by explaining one's actions. Each member of a social group can evaluate the arguments for each alternative and offer one's own arguments for open discussion (Baumeister et al., 2017; Frith, 2012; Mercier & Sperber, 2011). This benefits decision making in groups and enables an individual to learn the cultural norms concerning decision making and valid arguments.

A commonly held naïve view suggests that the conscious self is responsible for generating most behavior and is able to perceive surroundings in an accurate way. However, both of these assumptions appear to be illusions (Baumeister & Masicampo, 2010; Wegner & Wheatley, 1999). According to the current view, conscious thinking instead generates and modifies intentional action plans or schemas that are otherwise executed rather automatically (Baumeister & Masicampo, 2010; Fernandez-Duque, Baird, & Posner, 2000), such as "after breakfast, I will drive to work." When we have a conscious plan to drive to work, we do not need to consciously stay on the right (or left) side of the road, because we have learned to do it automatically. The illusion of conscious control is probably related to the fact that we *could* take control of each voluntary muscle, but there is rarely any need to do so. As long as our behavior is consistent with our goals and conscious thoughts, we feel that we are in control of our actions (Baumeister & Masicampo, 2010; Doris, 2018; Wegner & Wheatley, 1999).

However, when we must take a more controlled approach to a specific task, for example because it is unfamiliar, an organized form of conscious thought, inner speech, comes to help and appears to have a significant role in the voluntary guidance of action and goal-directed action (Bastian et al., 2017). Inner speech enables the following of explicit verbal rules, for instance when learning, by activating neural circuits endogenically (Baars, 2005): it guides attention to thoughts and therefore controls thinking (and thus behavior) by using words as pointers to specific action plans (Martínez-Manrique & Vicente, 2010). Internal monologue thus often accompanies skill acquisition (M. D. Lieberman, Gaunt, Gilbert, & Trope, 2002) and verbalization can significantly improve learning in certain tasks, for example in dynamic decisions by guiding attention to relevant information in the right instances (Berry, 1983; Berry & Broadbent, 1987). Impending inner speech with articulatory suppression can distract the functioning of voluntary attention when the individual is required to alternate between tasks (Baddeley, Chincotta, & Adlam, 2001; Emerson & Miyake, 2003). This can induce mind-wandering, as people's ability to focus attention by means of inner speech is weakened (Bastian et al., 2017). This focusing of strategic attention appears to be specifically linked to language; suppressing visual or auditory processing does not have an effect on mind-wandering. Inner speech is salient to introspection, emphasizing the importance of the controlling role of language in conscious thoughts.

Conscious thoughts can influence subjective experience (Winkielman & Schooler, 2011): reading a book or a news story, for instance, may induce strong emotions. Social environment can therefore affect our experiences greatly via the use of language. Language, on the other hand, can make fuzzy experiences more precise by naming them (Colombetti, 2009). Thus, when people explain their judgments, their subjective explanations reflect the interaction between the experience and conscious thoughts rather than being a one-directional transform of experience into verbal description. As mentioned earlier, thoughts guide attention (O'Regan & Noë, 2001) and attention alters experiences by shifting the focus onto different aspects of experience (Lee, Frederick, & Ariely, 2006; Tse, Reavis, Kohler, Caplovitz, & Wheatley, 2013; Yamada et al., 2014). What follows is that individuals' thoughts can become dissociated from their original experiences, for example due to social pressure, when thoughts direct attention away from some relevant aspects of the original experience (Winkielman & Schooler, 2011). Explaining can therefore interfere with judgments that are based on subjective experience, leading to changes in preferences (McGlone, Kobrynowicz, & Alexander, 2005; Wilson et al., 1993; Yamada, 2009).

1.2 JUDGMENT AND DECISION MAKING

How does the dynamic and multidimensional experience then become a one-dimensional rating or categorical choice? For example, when asked to judge image quality and to choose the better of two images, we may experience the first as having somewhat faded colors, but at the same time, we see it is also clear and well-lit. In the other image, colors can be brighter, but it is dark and fuzzy. How do we decide which of the alternatives is better? Psychological research on judgment and decision making (JDM) aims to explain, among other things, the ways people integrate such multidimensional information into preferential judgments when they have to make a choice between two or more alternatives. In these cases, people may be required to take into account several *attributes*, which have a different subjective importance (Bettman, Luce, & Payne, 1998). For example, the choice of an apartment may be dependent on such attributes as location, size, price and condition, each of these having a different importance or *attribute weight*.

The psychology of JDM has been heavily influenced by Herbert Simon's idea of *bounded rationality*, which refers to the cognitive and contextual limitations in human decision making (H. A. Simon, 1955). People do not have, for instance, endless time to deliberate their every decision. Another influential view has been the idea that people may not have well-defined preferences, but the preferences are often constructed on-line when individuals are confronted by choices: they reach decisions by conducting a conscious calculation about the attributes of the alternatives and not by referring to existing preferences (Bettman et al., 1998). As human conscious thinking is limited in several respects, these calculations and hence rationality has been assumed to be bounded by these limitations. The most important limitations in human conscious thinking are caused by the working memory capacity and serial processing (Evans, 2008; Evans & Stanovich, 2013).

It has been assumed that people can overcome the computational limits of their conscious thinking by using different strategies or heuristics on the basis of the needs of the current decision (Payne, Bettman, & Johnson, 1988). When human decision making behavior does not follow the principles of normative rationality, the reason for this has therefore been assigned to bounded rationality and to the accompanying strategies that people use. For example, when people fail to follow the rule of transitivity, it could be explained by the use of a certain strategy that ignores part of the information (Tversky, 1969)[5].

Until recently, the study of judgment and decision making has not given much attention to the role of consciousness. When discussion on the bounded rationality has referred to the computational limitations of human cognitions, it has implicitly assumed that rational judgment and decision making is based

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[5] Intransitivity occurs when individual's pair-wise choices of three alternatives, A, B and C, follow a pattern of preference where A > B, B > C and C > A, where > indicates preference. In other words, alternatives cannot be ordered, which contradicts the axiom of transitivity in rational economic behavior.

on the processes that are based on conscious thought, or *analytic thinking*, which is usually described as slow, conscious, deliberative, serial and controlled (Denes-Raj & Epstein, 1994; Epstein, Pacini, Denes-Raj, & Heier, 1996; Evans & Stanovich, 2013; Kahneman, 2003; Stanovich & West, 2000).

Subjective experiences, as results of intuitive, non-conscious processes were, for a long time, described as a source of biases and irrationalities that prevent rational behavior. This dual-process view, contrasting between analytic and intuitive cognition, has become widely known, especially when Daniel Kahneman received a Nobel Prize in economics. Kahneman's (2003) research program was based on revealing biases in human reasoning and decision making and explaining these biases by referring to a wide set of heuristics that occur within intuitive thinking. Within this 'heuristics and biases' tradition, judgments and decisions that somehow break the rules of rationality have been attributed to intuition, whereas normative behavior has been associated with the use of reason, or conscious, analytic cognition. This is also in line with folk psychological ideas about rationality.

It indeed appears that conscious thought influences rationality by enabling the application of culturally shared normative rules or other people's advice in decisions (Baumeister, Masicampo, & Vohs, 2011; Briley, Morris, & Simonson, 2010; Frith, 2012; Hofmann & Wilson, 2010), which people gradually learn to apply automatically (Baumeister et al., 2011). Conscious thinking is also assumed to benefit tasks requiring reasoning or manipulation of exact information, such as numbers (Hammond, Hamm, Grassia, & Pearson, 1987; McMackin & Slovic, 2000; Reyna, 2012; Rusou, Zakay, & Usher, 2013). Conscious thought can integrate behavior across time, as individuals can reflect their previous actions and accommodate their decisions according to them; without consciousness people would respond only to immediate inputs (Baumeister et al., 2011). Conscious thought can therefore facilitate rationality by increasing consistency in the long run, by creating meaning for a series of actions: Gazzaniga (1989), for example, suggests that the left-brain 'interpreter' constructs theories about actions and experiences by generating hypotheses about the causal chains behind the actions. Although these hypotheses can be seriously wrong, explicit hypotheses about the reasons for successful decisions can also be utilized in future decisions, which enhances learning (Baumeister & Masicampo, 2010; Frith, 2012; Hagafors & Brehmer, 1983). These hypotheses are thus tested and wrong hypotheses can be discarded.

Contrasting the traditional view of analytic thinking as the source of rationality, attitudes towards the role of consciousness have traditionally been more skeptical in the social psychological research tradition (Bargh & Chartrand, 1999; Nisbett & Wilson, 1977; Wegner & Wheatley, 1999). Also the study of the naturalistic decision making among different professionals suggest that expertise is mostly based on intuitive skills, not on rational reasoning (Kahneman & Klein, 2009; Lipshitz, Klein, & Orasanu, 2001; Reyna, 2012): many experts categorize situations rapidly and follow an action plan associated with that categorization (Klein, 1993). No conscious evaluation between alternatives is usually made. These perspectives and additional neuropsychological evidence have had much influence on the contemporary view that rationality is not synonymous with conscious reasoning and irrationality with emotions or results of non-conscious processes present in subjective experience. Damasio (Bechara & Damasio, 2005; Damasio, 1994), for instance, has shown that the human ability to decide is largely dependent on emotions: damage in the brain areas that process emotional information can severely distract people's ability from making rational decisions, or decisions at all, in spite of their intact intellectual abilities. The role of affect in rational decision making has also been supported with some experimental evidence (Lee, Amir, & Ariely, 2009; Pham, 2007). In general, affect appears to be the 'common currency' between alternatives that are otherwise difficult to prioritize (Weber & Johnson, 2009). Our everyday lives tend to rely on automatic routines, or intuition; additional deliberation can, in fact, can cause confusion in many ways by interfering with established routines and intuitions, making us uncertain about our preferences (Betsch, 2011; Simonson, 1989; Wilson et al., 1989).

Generally, the role of conscious thinking in JDM has probably been overestimated (Williams & Poehlman, 2017). In the previous section it was pointed out that we usually feel control over our behaviors as long as they are consistent with our goals and thoughts (Dijksterhuis & Aarts, 2010; Gallagher, 2000; Wegner & Wheatley, 1999). It also appears that it is an important human tendency to create meaningful narratives for events (Epstein, 1994; Gazzaniga, 1989) or arguments for judgments and decisions (Mercier & Sperber, 2011), without significant effort. This occurs even when there is no information available (Turk et al., 2003). The low amount of effort suggests that this is an automatic, or intuitive, feature of human thought. Interestingly, some experiments suggest that conscious thoughts can be evoked unintentionally by perceptions, even against one's intentions (Bhangal, Allen, Geisler, & Morsella, 2016). Analytic thinking, on the other hand, involves effort, voluntary manipulation and critical assessment or examination of the arguments or narratives. The fact that judgmental processes are *accompanied* by thoughts, therefore does not necessarily mean that the judgments are *based* on thoughts (Williams & Poehlman, 2017). This might explain why people feel that their behaviors are directly caused by thoughts.

It now appears widely accepted that processes that are not based on conscious deliberation can sometimes be superior in JDM, especially in complex decisions (Dijksterhuis, 2004; Glöckner & Betsch, 2008b; Levine, Halberstadt, & Goldstone, 1996; Usher, Russo, Weyers, Brauner, & Zakay, 2011). Automatic processes offer efficiency and speed and therefore they are used in most everyday decisions and judgments. These processes, working outside conscious thought, are not overloaded with information and function faster than conscious deliberation.

Intuition is regarded as a common name for this diverse set of automatic processes that function outside our conscious awareness so that only the results of these processes become phenomenally conscious as experiences (Evans & Stanovich, 2013; Gore & Sadler-Smith, 2011). Intuitive thinking is based on learning (Hogarth, 2001; Reyna, 2012) and it is linked with expertise (Kahneman & Klein, 2009). Although some authors suggest that these non-conscious, intuitive processes follow similar rules as conscious thinking (Kruglanski & Gigerenzer, 2011), others suggest that intuitive thinking is free from the limitations of conscious thought (Dijksterhuis & Nordgren, 2006; Glöckner & Betsch, 2008b; Usher et al., 2011): when the capacity-limited working memory is not needed, there is no need to restrict the amount of information, which can be automatically processed in parallel with effective associative mechanisms, without voluntary control (Glöckner & Betsch, 2008a; D. Simon, Pham, Le, & Holyoak, 2001). These pattern recognition mechanisms aim to find a decision which maximizes the coherency of the solution and minimizes the conflict that is involved in the choice. This often includes decreasing the weight of the conflicting information and increasing the weight of the coherent information. This is in line with the property of subjective experience to present the world as coherent and non-conflicting: the solutions to the decision problems resemble the unique gestalts familiar from perceptual psychology. The pattern recognition view of automatic JDM contrasts with the traditional multiple-strategy view, or 'adaptive toolbox' approach, which suggests that people adapt to different decision making requirements by changing the algorithmic strategies that they use (Glöckner & Betsch, 2012; Glöckner, Hilbig, & Jekel, 2014).

Therefore it has been suggested that *information integration* in decision making is mostly automatic and non-conscious, without the intervention of the working memory, and it is actually *information acquisition* where deliberation can sometimes have a crucial role (Dijksterhuis & Nordgren, 2006; Glöckner & Betsch, 2008a). The former process is responsible for weighting and integrating information about each alternative into gist representation, on which a decision is then made (Abadie, Waroquier, & Terrier, 2013). The gist summarizes the information about the alternatives and therefore facilitates the comparison between alternatives when the amount of information is large. The information acquisition process, on the other hand, helps to bring all the decision-relevant information into consciousness and it is based on the use of voluntary attention in the guidance of conscious thoughts. Information search can be slow and can require great effort; in such cases fast and frugal heuristics can be highly useful (Gigerenzer, Todd, & the ABC Research Group, 1999).

After being presented in the phenomenal consciousness, this information is available for automatic decision processes (Morsella et al., 2016). Recent experiments on unconscious thought phenomena suggest that representing the relevant information in consciousness in a specific way is required in order for the unconscious information integration processes to work properly

(Abadie, Villejoubert, Waroquier, & Vallée-Tourangeau, 2013; Nordgren, Bos, & Dijksterhuis, 2011). Conscious thought, on the other hand, can help overcome the biases in how information is sought and brought into phenomenal consciousness (e.g. Kahneman, 2003), not in how it is integrated.

Sometimes, the first impression in subjective experience as such is not enough to determine a clear preference, and additional, conscious reasoning is required to come up with a resolution. In unfamiliar contexts, an individual may not able to distinguish between relevant and irrelevant dimensions (Hoeffler & Ariely, 1999) and there might not be existing routines to follow (Fernandez-Duque et al., 2000; Verplanken, Aarts, & van Knippenberg, 1997). Such is the case where the individual has not yet learned intuitions related to the task in question. As a result, subjective experience may lack a clear preference dimension and may consist of more than one relevant dimensions and the individual must consciously determine the importance of these dimensions in order to determine the preference order of the alternatives.

Fluent processing appears to be a sign that informs the individual that learned automatic processes are working well and means a greater confidence in intuition (Alter, Oppenheimer, Epley, & Eyre, 2007). Conflict tends to distract fluent, automatic processing, shifting the process to a more deliberative mode and the individual can apply more flexible voluntary processes. Activation of the anterior cingulate cortex has been found to be associated with decision conflicts, and this activates the prefrontal cortex which is responsible for controlled processes (Alter et al., 2007; Botvinick, 2007; Fernandez-Duque et al., 2000; Morewedge & Kahneman, 2010). In the case of JDM, reason-based processes are activated when the alternatives appear to be equally appealing, unpleasant or conflicting (Shafir, Simonson, & Tversky, 1993).

Morsella et al. (2016) suggest that the function of phenomenal consciousness is to represent those kinds of conflicts that involve selections between different action plans or choices. Therefore it appears that knowing these dimensions of experience is crucial for understanding on what subjective information the decisions and judgments are based. This was the underlying idea in the development of the interpretation-based quality method.

1.3 INTERPRETATION-BASED QUALITY APPROACH

This dissertation stems from the *Interpretation-Based Quality* (IBQ) approach (Nyman, 2010; Nyman et al., 2010, 2008, 2006; Nyman, Radun, Leisti, & Vuori, 2005; Radun et al., 2008). As it has been discussed so far, human subjective experience is dependent on personal factors, such as learning history and interpretation of the stimuli. Individual preferences, on the other hand, tend to be dependent on how people experience the stimuli. Therefore, preferences should be both subjective and contingent on how stimuli are experienced. The IBQ approach was developed to find the dimensions of experience that determine decisions related to subjective preferences. The basis of this method is a combination of psychometric evaluation of quality and qualitative description of subjective dimensions of quality.

Psychometric evaluation usually means a combination of judgment and decision: for example, in the paired comparison method participants are asked to judge which of the presented images is better and choose it accordingly; or when participants are asked to rate the quality of single images on a scale from 1 to 10, for example, they are asked to decide which numerical value they would assign to the stimuli on the basis of their judgment. The resulting quantitative data informs, for example, how a certain image signal processor (ISP) in a digital camera performs in comparison with other processors. These values are usually reported as the mean opinion scores (MOS), which simply averages test participants' ratings that are given to a specific image. In the field of digital cameras several standards, both objective and subjective, have been developed for the measurement of image quality.

The MOS has traditionally been defined as the target for objective or computational methods for measuring image quality automatically, directly from the images. The purpose of the objective image quality (IQ) metrics is to avoid tests involving human observers, which are labor-intensive and expensive. In many cases, subjective testing is not even possible. For example, the information stream in a digital television system can be optimized by using objective IQ metrics automatically, on-line. The development of these objective metrics is a field of study which has a history of over 40 years and the number of developed metrics has increased at a fast pace (Pedersen, 2015). As a result, objective IQ metrics are ubiquitous. For example, an objective IQ metric called SSIM (Wang, Bovik, Sheikh, & Simmoncelli, 2004) won a Primetime Emmy Award in 2015 for its wide use in digital television quality control. SSIM as well as many other metrics (e.g. visual information fidelity, VIF; Sheikh & Bovik, 2006) try to approach IQ by mimicking the human visual system. The incorporation of this low-level neural knowledge in objective metrics is not a final solution for reliable IQ measurement as the correlation between the MOS values and the results of these metrics is far from perfect. In a recent evaluation of 60 state-of-the-art metrics, none reached the linear correlation of .80 with subjective ratings (Pedersen, 2015).

Contrary to the approach that aims to measure image quality physically, directly from the images, the IBQ paradigm emphasizes the subjectivity of the quality evaluation, high-level vision, decision making processes and the end-user point of view: participants are naïve – as end-users usually are – and they are told that there are no right or wrong answers. This subjective perspective can cause unpredictable variations in quality evaluations that are beyond the capabilities of objective metrics that are based on low-level vision. In the IBQ, the instructions and research set-ups are based on standard practices in experimental psychology and are therefore designed to provide as reliable as possible data from individual participants (e.g. Nuutinen, Virtanen, Leisti, Mustonen, & Radun, 2016).

In order to understand the subjective evaluation process more thoroughly, the IBQ method requires a subjective explanation for each decision. Usually participants are simply asked to give the reasons on which their judgments are based, by referring in their own words to the properties of the images. The assumption is that these explanations reveal something of the experience on which the evaluation is based. From these explanations, relevant attributes of the decisions are sought by using an appropriate qualitative coding scheme, usually grounded theory (Strauss & Corbin, 1998), which emphasizes the participants as the only source of the decision attributes. Thus, analysis is not made with any predetermined attribute set defined by the researchers, neither are the participants given a ready-made set of attributes that should be used.

Coding of the explanation data is an iterative process, where the coder first gathers all the attributes that have been used by the participants, and after this open coding phase, synonyms or very similar codes are gradually merged (Radun et al., 2008). Finally, the attributes that have only been used a few times and cannot be merged with other codes are discarded. The result of the coding is a set of subjective attributes that is assumed to describe the relevant dimensions of a quality experience among the evaluated samples. This data can give a qualitative description of the factors that differentiate between good and bad quality in different contexts, such as camera use cases.

1.3.1 BACKGROUND FOR THE IBQ METHOD

1.3.1.1 Semantic gap between objective measurable properties and subjective attributes of quality

The initial reason for the development of the IBQ method was the semantic gap, which was found between the low-level perceptual properties of the visual stimuli and the relevant subjective concepts that people used when describing their experience of the quality of visual products (Eerola et al., 2011; Radun, Nuutinen, Leisti, & Häkkinen, 2016). This gap was especially large in the context of print quality of high-quality magazines, where the visual properties of the paper had a major impact on the impression that the magazine made on the consumer. Although the objective differences between prints concerned mainly such low-level properties as color, gloss or lightness, participants could use such concepts as 'warm,' 'soft,' ' bright' or 'clean' to describe their experience of quality (Eklund, 2001; Leisti, 2003). It may appear to be relatively easy to theorize associations between these subjective concepts and the objective paper properties *post hoc*, but, however, no current theories of visual perception *predict* the quality experience of the participants, nor the ratings that participants give, because their decisions are based on subjective interpretations (Radun et al., 2016). Therefore, the participants' interpretation of the objective properties of the stimuli were emphasized in the method.

The IBQ approach aims at *subjective-to-objective* mapping, which first defines the relevant phenomena occurring in the subjective experience and then seeks the objective parameters that could explain the occurrence of these phenomena (see Albertazzi, 2013; Felin, Koenderink, & Krueger, 2017). Using the data provided by the IBQ method, it is possible, for example, to build computational models that predict both quality experiences and ratings from the objectively measurable visual properties (e.g. Eerola et al., 2011). Without knowing the relevant subjective dimensions, this is impossible.

A similar approach was prominent in gestalt psychology and it is still widely used in vision science, for example, when visual illusions are used to study how the human visual system works (Albertazzi, 2013). This is in contrast to the traditional paradigm in psychophysics that first defines the relevant objective parameters and then measures the related dimensions in psychological experience (*objective-to-subjective mapping*). In the history of psychology, Gestalt psychology emerged from criticism towards psychophysics, and the idea that subjective experience could be understood by dividing it into its constituents, and the physical counterparts of these constituents. Gestalt psychology relied on phenomenological ideas that emphasize the special character of subjective experience (Albertazzi, 2013).

1.3.1.2 Multidimensionality of subjective quality and the inverse problem

An important and inherent aspect of quality experience is its multidimensionality, whereas the quality rating typically informs only about product's location on a one-dimensional (good-bad, for example) quality dimension. For instance, the performance of digital cameras is dependent on several attributes. When the aim is to enhance quality and one has only data about quality ratings and of large number of camera's physical parameters, it is difficult to know how the camera quality could be enhanced. IBQ offers data which can be used when solving this *inverse problem* faced by engineers optimizing the imaging systems. Simple preference ordering often results in rather trivial data, leaving engineers and designers to guess the reasons why their products fail to reach the maximum level of quality.

1.3.1.3 Context-dependency of quality

Quality is context-dependent. Objective differences could be interpreted differently in different image contents, or in different products, such as magazines, and these different interpretations can lead to different judgments (Radun et al., 2008). Not only are image contents rated differently, objective image parameters are experienced differently in different contents. In terms of IBQ, the *decision space*, which is reflected in the subjective quality attributes, differs between different images, even when the objective differences are similar (Nyman, 2010; Nyman et al., 2010). Manipulating sharpness, for example, can induce different interpretations, depending on the content or the evaluator (Radun et al., 2008): if a blur in an image is interpreted as 'artistic', it is rated better than when it is interpreted as 'unsharp.' Figure 2 further illustrates this context dependency: Figure 2a is the original image from a digital camera, 2b is the manipulated version with a change in luminance level and color balance. The difference between the images can be interpreted as a difference in luminance level and color balance, but it can also be interpreted in relation to the image content, as a difference between two weather conditions: image a being shot in clearer sunny weather conditions, whereas image b is shot in wetter rainy weather.

How does the knowledge of phenomenal consciousness relate to the judgment of quality? The traditional approaches to image quality have been heavily influenced by psychophysics. The overall quality of an image is conceptualized as a combination of component attributes, or 'nesses,' such as sharpness, graininess, colorfulness, etc. (Engeldrum, 1999), which are further perceptual counterparts of combinations of certain objective, or physical properties of an image. The traditional view further has been that the combined effect of the physical quality parameters can be mathematically calculated from the effects of separate attributes using proper formula, such as Minkowski summation (Engeldrum, 1999; Keelan, 2002). However, the findings concerning the interpretative nature of subjective experience are problematic to any approach that aims to predict multidimensional subjective experiences on a psychophysical basis (Nyman et al., 2008): qualitative phenomena cannot be reduced to physical stimuli, as they come with interpretation, or meaning, which is assigned to the stimuli by the observer (Albertazzi, 2013). In JDM, meanings are further associated with personal learning and point of view (Reyna, 2012). The IBQ specifically aims to find out these meanings.

1.3.1.4 Subjectivity is not an error

Computational methods that try to predict human preferences directly from the physical properties of images are deterministic and have only a single ranking or rating of the alternative (Lin & Jay Kuo, 2011; Pedersen, 2015). They are tuned so that they would as closely as possible imitate the average judgments of humans, and differences between the ratings made by different individuals are therefore treated as unwanted errors. However, human preferences are subjective and can be dependent on the personal background and cultural factors (Bourdieu, 1984). Generally, perceived reality is not independent of the observer (Felin et al., 2017), and this manifests in *no-*

reference image quality[6] in particular: when a scene is captured by several cameras, none of them can be defined as the objective truth about how the scene really looks; images can only be subjectively ranked on the basis of how well they match with the human observer's subjective visual experience of the scene. Color balance and lightness levels in photographs do not have one objectively correct level; instead, many possible, equally natural solutions exist (Felin et al., 2017). What is the right solution is dependent on the interpretation. So, when different individuals give different ratings, it is not necessarily an error for they may experience the differences differently, as each subjective phenomenon is connected to a single point of view (Nagel, 1974). The differences in how things are experienced are not trivial, when they are found, for example, between different consumer segments.

Different introspections for the same stimuli were regarded as an unpassable obstacle for studying conscious phenomena at the beginning of the 20th century (Ericsson, 2003). This led to the use of meaningless stimuli in cognitive psychology, so that different interpretations do not interfere with the cognitive processes being studied. That subjective experiences of introspective observers differ is not a weakness in methodology, however, but a manifestation of individual differences (Costall, 2006): the subjectively experienced world is an important aspect of human life. Meaning is an inseparable property in many everyday cognitive processes (e.g. Reyna, 2012). Therefore IBQ stresses the subjective point of view and interpretations that are assumed to mediate how physical targets are evaluated.

1.3.1.5 The dimensions of judgment are subjective

Finally, and most importantly, the IBQ method relies on attribute data that is spontaneously produced by the research participants. The usual procedure to gather self-report data is to use Likert scales: for example, participants may be asked whether the image is sharp, colorful, natural, grainy, etc. Likert scales provide data that is quantitative and is usually normally distributed, that is, data that is easy to analyze quantitatively using standard methodology. The weakness of this approach is that we may not know *a priori* the personally relevant attributes of the judgment, and, more importantly, we do not know whether a certain participant really uses these attributes *when not asked about them*.

Personally relevant attributes are associated with a certain interpretation of the task and are accompanied by a specific information acquisition strategy (Radun et al., 2016). The real danger is that asking participants to make judgments on predefined attribute scales, their attention is diverted towards

[6] Image quality metrics are divided into full-reference, reduced-reference or no-reference types depending on the existence of an original, or reference image, which represents the highest quality example of the image which has not yet been, for example, compressed or transmitted. Reduced-reference metrics usually have some meta-data available about the original image.

these attributes in their judgments, instead of their initial focus, which is based on personally relevant attributes (Leisti, Radun, Virtanen, Halonen, & Nyman, 2009; Radun et al., 2016; Tordesillas & Chaiken, 1999). This may not only distract their judgments (Wilson & Schooler, 1991), it may also manipulate their subjective experiences, which are dependent on the focus of attention (Tse et al., 2013; Yamada et al., 2014). For example, if a participant is asked whether the duck in the image looks left or right, we may not see the rabbit (Figure 1). So, if the researcher is interested in the experiences, using a predetermined scheme for evaluating the experience may in fact distract the authentic experience that is being studied.

1.3.2 APPLICATION OF THE IBQ METHOD OUTSIDE THE CONTEXT OF IMAGE QUALITY

The emphasis of the approach was first on the concepts that consumers and experts used to describe the quality of high-quality magazines (i.e. prints: e.g. Eklund, 2001; Leisti, 2003). Later, the psychometric approach in IBQ gained more emphasis, when the method was applied to digital printing and image quality (Leisti et al., 2009; Nyman et al., 2005), a context, which was strongly based on the tradition of psychometrics and psychophysics (Engeldrum, 2000; Keelan, 2002). Gradually, the use of the method was extended to, for example, video quality (Radun, Virtanen, Olives, J. L., Vaahteranoksa, Vuori, & Nyman, 2007), 3-D image quality (Shibata et al., 2009) and 3-D movies (Häkkinen et al., 2008), among others. Internal validity appeared to be good in all applications: it was shown that participants use attributes in a consistent manner, when examined over all participants using a suitable methodology, such as correspondence analysis (Greenacre J., 1984): attributes usually form a clear low-dimensional space, with meaningful dimensions that can be related to objective physical properties. The reliability of the method has been examined as inter-rater reliability and it has ranged between fair and excellent, depending on the attribute (Radun et al., 2008).

1.3.3 RELATED APPROACHES

1.3.3.1 Thinking-aloud method

The IBQ approach has some superficial resemblance with the *verbal protocol* method (Newell & Simon, 1972), which has been employed in decision-making research from the 1970s (e.g. Payne, 1976). A typical use of this method means that participants are presented with decision problems, they are asked to solve them and verbalize all their thought during the task. For example, a decision could consist of selecting an item (such as an apartment) from a limited number of alternatives, which are described by a limited number of attributes (such as rent, size or condition). Participants are only asked to think aloud, not interpret or explain their answers (Ericsson & Simon, 1980; Fox, Ericsson, & Best, 2011). Participants' verbalizations are recorded, transcribed and coded according to the information search patterns the participants use. On the basis of this qualitative analysis, conclusions are made about the decision-making strategies of the participants. Verbal protocols (in addition to so-called information display and gaze-tracking methodologies) are part of the process-tracing approach that emerged to complement the structural approach to decision making (Harte, Westenberg, & van Someren, 1994). These methods aimed at explicating the psychological process that preceded decisions, instead of just modeling the decisions using statistical methods such as regression analysis, which practically regard the underlying psychological process as a 'black box.'

In order to respond to the criticism towards introspective methods (particularly Nisbett & Wilson, 1977), Ericsson and Simon (1980) built a theoretical basis for thinking-aloud methodology, where the emphasis was on conscious thought using the working memory and a verbal code. Ericsson and Simon avoided using language that would refer to subjective experience or conscious thought, apparently to avoid the "introspectionist" stigma (see Ericsson & Fox, 2011). Nor did they recommend using the thinking-aloud methodology in tasks that involve perceptual stimuli, which would require recoding the perceptual experience into verbal reasons. Thinking aloud on verbal decision problems should produce valid data, because it is assumed that it does not require transforming information from a perceptual to a verbal code, which could lead to omissions and distortions. In other words, all the data that is acquired, manipulated and articulated should stay in the working memory and does not get contaminated by non-conscious processes that cannot be verbalized. Therefore Ericsson and Simon do not warrant the use of thinking aloud when judgments are made on perceptual stimuli. Much evidence has accumulated over the years to support their theory (Fox et al., 2011).

Interpretation-Based Quality relies on a very different paradigm in comparison to the think-aloud approach. The IBQ approach differs from these methods in a sense that it is not focused on the process or conscious thoughts; instead, it is supposed to reveal the *subjective experience* behind the judgments, or the subjective *decision space* (Nyman, 2010; Nyman et al., 2010; cf Morsella et al., 2016) that accompanies judgments of quality. This space consists of all dimensions of subjective experience that participants consider relevant in their judgments of quality, usually consisting of a set of personal, subjective attributes. The IBQ method does not make strong commitments on the strategies that are used to integrate this experiential information into a single rating of quality (Leisti et al., 2009). It may be that humans have direct conscious access only to the decision space represented by the subjective experience; the processes that result in subjective experience, or the processes form judgments on the basis of subjective experience may well be unconscious (Morsella et al., 2016). However, it is possible to combine descriptions of experience with process measures, such as eye movement recordings (Radun et al., 2016).

Think-aloud methodology and the IBQ method therefore take an opposite stance on the subjectivity of judgment and decision making. Inferring underlying processes on the basis of thinking aloud also requires that processes leading to decision are conscious. Considering the role of conscious thinking in everyday judgments, thinking aloud can provide information about quite a marginal sector of the whole spectrum of human JDM processes. Although many decisions are not based on conscious thought processes, they still require representing the information in the phenomenal consciousness in order to become integrated into JDM processes (Nordgren et al., 2011).

1.3.3.2 Qualitative sensory evaluation methods

The IBQ method has methodological relatives in chemical sciences, in the sensory evaluation of food and beverages. These methods specifically concentrate on subjective experience, that is, how certain food tastes, smells and feels. An example that is familiar to many is wine tasting. Many magazines, books and newspapers provide articles where they offer quality ratings with wines and qualitative evaluation of the wine's taste, smell and the appearance of the wine. Qualitative description is often as relevant as the actual rating: it informs the reader about the context of the judgment, for example, with what kind of foods the wines should be drunk. On the basis of these descriptions, consumers can also get some kind of idea whether they would like the wines themselves. These kinds of evaluations are, after all, subjective, even when they are made by an expert.

Various methods for describing the taste or feel of foods and drinks exist in the sensory evaluation tradition (Faye et al., 2004; Varela & Ares, 2012). Methods differ according to the participant groups evaluating the product (experts vs. naïve participants), use of evaluation made by individuals or groups, the way experiences are described (free descriptions or consensus vocabulary), etc. In addition to food testing, similar qualitative testing has been used in audio quality evaluation (Lokki, 2016; Lokki, Pätynen, Kuusinen, & Tervo, 2012; Olive, 2004) or in the evaluation of textile materials (Picard, Dacremont, Valentin, & Giboreau, 2003), for instance. The approach in these applications is generally pragmatic and empirical. On the other hand, these methods do not usually claim to describe the process of judgment; their purpose is only to make the basis of quality judgments understandable.

1.4 CAN REASONS FOR DECISIONS BASED ON SUBJECTIVE EXPERIENCES BE VERBALIZED?

The underlying assumption in this dissertation is that people's subjective explanations for their preferences provide useful data, as the applied use of the methods would suggest. A certain school of psychological basic research suggests the opposite: conscious thinking, the source of explanations, has a rather marginal role in everyday choices that people make and people usually manage quite well without additional deliberation. Therefore, the explanations, as the reflections of conscious thoughts, should have little to do with the authentic JDM process.

Furthermore, explaining appears to be a disadvantage in many tasks (Dijksterhuis & Nordgren, 2006; Dijksterhuis, 2004; Levine, Halberstadt, & Goldstone, 1996; McGlone, Kobrynowics, & Alexander, 2005; McMackin & Slovic, 2000; Wilson et al., 1993; Wilson & Schooler, 1991): when people are asked to explain their choices, it is assumed to shift processing towards a more conscious and analytic mode, which is unfit for certain tasks (Baumeister et al., 2011; Chin & Schooler, 2008). Because of this shift, participants' explanations should represent culturally plausible reasons for their preferences, instead of the real reasons that remain inaccessible (Johansson, Hall, Sikström, Tärning, & Lind, 2006). In the following sections, I will review this evidence from basic research and interpret it in the context of the assumption of the usefulness of verbal data. On the basis of this analysis, I will define the research questions and hypotheses for this dissertation.

1.4.1 CONSCIOUS ACCESS TO HIGHER COGNITIVE PROCESSES

When Nisbett and Wilson (1977) reviewed the empirical evidence about people's ability to introspect their choices, they concluded that

> *...there may be little or no direct introspective access to higher order cognitive processes.*

Nisbett and Wilson suggested that people explained their actions by creating causal theories about why they should have acted in the way they acted. Usually, these should just be culturally shared 'stock-pile' explanations that give a plausible causal account of the reasons for one's actions. Similar views have been later presented, for instance, Dennett (1991) and Gazzaniga (1989). Nisbett and Wilson (1977) as well as philosophers like Carruthers (2010) thus suggest that people are aware only about their *mental states*, not their *mental processes*.

We can take an example from, say, mental states and processes related to memory. We can recollect memories from the past and we are of course aware of them. These are mental states. However, we are not aware about the process that brings these past events to our minds. We can only be aware of the preceding memories, i.e. mental states. Similarly, it can be conceived that we are aware of our experiences, but we are not aware of the rapid low-level perceptual processes that either produce them or of the subsequent processes that consume them. The latter processes may include, among others, information integration processes that end up in decisions.

As was earlier mentioned, contemporary knowledge suggests that we first see more general aspects, or gist, and only then examine the details (Crick & Koch, 2003; Hochstein & Ahissar, 2002). Detection of familiar objects is extremely fast (Thorpe, Fize, & Marlot, 1996) and we are immediately able to categorize objects in different classes. For example, we instantly perceive a dog, but we are unable to retrieve the process that infers that a certain object is a dog. If we are asked why we have reached that conclusion, we may explain that the animal has four legs, it is hairy and it barks. This explanation is hardly the description of the process, but a description of the culturally shared concept of 'dog.' We rather first see a dog, and then, by examining the details, such as the number of legs and amount of hair, verify that this indeed is a dog. Similar decision mechanisms, based on the immediate recognition of the situation and the accompanying solution, have been found with experts (Klein, 1993). The idea of stock-pile explanations therefore appears to have support in the perceptual domain.

Similar categorization processes can sometimes determine our preferential decisions as well: we are, for example, able to instantly discriminate good art from bad art (Nordgren & Dijksterhuis, 2009). If we are asked to explain this judgment, we probably do not describe the underlying process; instead, we can verbalize cultural norms about what is considered good art. Perceptual judgments rarely come in isolation; instead, they are often accompanied by a rich subjective experience. Becoming immersed in this experience is an important part of aesthetic enjoyment (Leder, Belke, Oeberst, & Augustin, 2004). So, it is equally possible that we stop and think why we like something or not, and then describe the positive and negative experiences that are related to those pieces of art. These experiences might not be the description of the underlying process; nevertheless, it is a description of the reasons for liking or not liking certain art, the description of the art experience that is the basis of the judgment.

In the case of art, this kind of description requires expertise (McGlone et al., 2005; Yamada, 2009). When people get familiar with the targets of their judgments, they learn to discriminate the aspects that are related to their evaluations (Dijkstra, Van der Pligt, & Van Kleef, 2013). Instead of just judging whether something, say beer, is more or less drinkable, an individual is able to discriminate different aspects of taste after having more experience with different kinds of beers (Hoeffler, Ariely, West, & Duclos, 2013). We learn to associate certain features with good quality and certain features with bad quality. This represents the development of expertise, or connoisseurship in the context, and this is accompanied by the development of self-understanding in the JDM processes (Dijkstra et al., 2013). For everyday targets, this kind of learning appears inevitable, as long as one is exposed to different kinds of targets, so how different aspects affect experience can be learned (Hoeffler et al., 2013).

It is, of course, always possible that subjective experience is not an exhaustive explanation for our actions from the *third-party* viewpoint, the perspective of the "all-seeing" researcher, who knows all the independent variables in the experiment (e.g. Nisbett & Wilson, 1977). Still, subjective experience is usually an exhaustive explanation from the first-person point of view[7] (Petitmengin & Bitbol, 2009). We may not be aware of the context from which we interpret our perceptions (Baars, 2005; Zeki & Bartels, 1999), but these interpretations are an integral part of our experience. Becoming aware of a certain factor can change the experience, not because it has not been taken into account before, but because the interpretation of the stimuli changes (Lee et al., 2006). The actions of an individual are not determined by the objective physical stimuli, but how these stimuli are interpreted and thus presented in the phenomenal consciousness. A researcher may infer these interpretations from subjective explanations when these explanations are compared with objective data or other people's explanations. From the scientific point of view, proper experimental setting and some knowledge of what the participant is judging is required to make the subjective interpretations understandable. Understanding the decisions of an individual may not need a thorough description of the process, the description of the decision space present in phenomenal consciousness is usually enough.

Moreover, the distinction between the concepts of the mental state and the process has been criticized (White, 1988), and it seems to ignore humans as active perceivers. Although there are component processes that are non-conscious, there are also processes that are under voluntary control, information search processes in particular. As was brought up earlier, subjective experience is not a static mental state, it results from interaction with the environment: what we attend to greatly influences how we experience things. Furthermore, voluntary attention appears to be very closely controlled by the same processes as conscious thought (Baddeley et al., 2001; Emerson & Miyake, 2003). It has been experimentally shown that this also works the other way round: Participants' subjective reports about their mental processes during a search task are found to correspond well with the actual eye

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[7] Sometimes, however, there is a wide semantic gap between the objective properties of stimuli and the subjective experience, for example, when aesthetics are concerned: a well-designed object is sometimes just beautiful, and it may be difficult to verbalize reasons for the kind of beautifulness it represents, especially without formal art education. Neural representations that are activated may not reach the level of quality that would make them conscious, but they still can affect processes on the preconscious level (Cleeremans & Jiménez, 2002). Sometimes there is nothing else than a metacognitive feeling of preference (Price & Norman, 2008). People should not be pressured into providing specific explanations in these cases. Instead they should have the right to be unsure and still make a decision.

movements performed by participants (Marti et al. 2015). More importantly, false reports seem to reflect a dissociation between the strategy and eye movements, not between the strategy and reports. This suggests that the reports are authentic descriptions of the strategic process that guides eye movements, not inferences that are made on the basis of overt behavior (eye movements). Participants are found to be aware of the attention shifts that precede eye movements even when they are not aware of the preceding primes that caused the shifts (Reyes & Sackur, 2017).

So, as a conclusion, it appears that we can become aware of the subjective experience itself, and learn to distinguish the relevant features in subjective experience that are the basis for our judgments and how attention to these different features can change the subjective experience. We should be able to tell what we are attending, and we can become aware how this affects our subjective experience of the outside world. Concerning the JDM tasks, it therefore seems that we can become aware of the information that is directed at the judgment processes, and, moreover, we may influence judgments by actively selecting information. Learning these interactions presumably has a significant role in how we understand the aspects that influence our judgments and decisions. Awareness of our JDM processes is not an all-or-nothing phenomenon, rather it is a learned metacognitive ability. Self-understanding about one's judgment processes in familiar contexts appears to be a general, not a specific, meaning that we generally seem to understand why we like or do not like certain things although we may not be able to access the specific process in question.

1.4.2 EXPLANATIONS AS FABRICATIONS?

Nisbett and Wilson (1977) showed that people may not be able to report all the relevant information that influences their choices. In other words, people may *omit* this information, at least from a third-person perspective. However, more crucial appears to be the finding that normal healthy people may *fabricate* the reasons or even intentions for their choices: Johansson, Hall, Sikström and Olsson (2005) showed a peculiar phenomenon that supports this account: first, participants were presented faces on two cards and were asked which of the faces they preferred. The experimenter then changed the cards (by performing a card trick) and presented the face that the participant did not choose and asked for explanations for that decision. Without noticing the manipulation, a large majority of the participants ended up fabricating both their intentions and reasons in order to explain the choices that they had not made. No difference was found between the explanations of the manipulated and non-manipulated trials, suggesting that the processes that produce these explanations do not differ between these conditions (Johansson et al., 2006).

The difficulty of detecting fabrication is the fact that even if explanations for choices correspond perfectly with the objective facts, it does not rule out the possibility that participants fabricate the answers. It may only show that their theories about the reasons for their choices correspond well to the objective reality. Fabrication only becomes evident when the explanations are obviously wrong (Gazzaniga, 1989; Johansson et al., 2005). It has been suggested that the causal narratives that people create to explain their own actions do not differ from narratives that are created to explain the actions of others (Dennett, 1991; Mercier & Sperber, 2011; Nisbett & Wilson, 1977; Wilson, 2002). The study of Johansson et al. (2006) appears to support this claim. Furthermore, some authors have concluded that conscious reasoning plays only a small role in decision making in general and that its function is mostly argumentative (Mercier & Sperber, 2011; cf. Baumeister & Masicampo, 2010). In other words, reasoning is supposed to justify, not determine, intuitively derived judgments and decisions.

Nisbett & Wilson's (1977) findings have been critically examined by authors who emphasize the differences between interpretation and the description of subjective experience (Petitmengin, Remillieux, Cahour, & Carter-Thomas, 2013). Interpretation in these cases refers to the causal inferences that are created to explain why individuals acted in the way they did. The problem is that we are not aware of this interpretative process (Carruthers, 2010), which easily occurs when people are under social pressure to provide an explanation for their actions. Most findings on fabrication have been based on experiments that rely on retrospective reporting, and more importantly, on cases where participants have not known that they would be interviewed later on the reasons for their choices (e.g. Johansson et al., 2005; Nisbett & Wilson, 1977). It is probable that little memory traces are left in the kinds of trivial decision tasks that have been used in the studies that have shown the human tendency for fabrication, which appears to occur when the reasons for decisions cannot be accessed.

True introspection should not theorize *post hoc*, or interpret the relations between mental events, but should describe mental states as they are (Carruthers, 2010; Petitmengin & Bitbol, 2009). When participants in the replication of Johansson et al.'s (2005) experiment were asked to concentrate on their experiences after the presentation of the alternatives and before explaining their choices, the number of participants unable to notice the manipulation dropped significantly (Petitmengin et al., 2013). The reason why the participants in the original experiment failed to notice the manipulation thus appears to be that they were not paying adequate attention to their experiences and choices.

Actually, Petitmengin and Bitbol (2009) suggest that introspection can intensify and amplify subjective experience, when practiced properly. Individuals should not acquire an observing stance towards their experiences and reflect on them. Instead, the aim is to become aware of the pre-reflective experience. In other words, they should experience, not think. Introspection in this sense resembles approaches such as mindfulness (Tang, Hölzel, & Posner, 2015). Other authors, who have originally shown the fallibility of introspection, have gradually shifted towards a view that introspection is in fact an ability (e.g. Hofmann & Wilson, 2010; Schooler & Schreiber, 2004). Participants' reports therefore seem to comprise a continuum, with different amounts of interpretation and description of subjective experience. With appropriate instructions, it is possible to influence where the participants' explanations are located on this continuum.

Recent findings suggest that visual experience often starts from a general gist and then proceeds to details in the guidance of attention (Crick & Koch, 2003; Hochstein & Ahissar, 2002). According to this view, the more general judgment of the visual scene precedes the perception of more specific attributes (Leisti et al., 2009). Visual preferences, for example, are often based on processing fluency (Reber et al., 1998), which can be experienced as perceptual clarity, as it makes the understanding of the image content easier. First, individuals can thus experience the image clearer, but on closer examination, by focusing attention on different parts of the image, they can notice (and further verbalize) that the image has better contrast and less blur and noise. They can reason that they like the image because the better contrast and the smaller amount of blur and noise makes it clearer. The preference is not the product of this reasoning, neither is the explanation necessarily a post hoc rationalization. Rather it is a deepening description of integral and dynamic subjective experience where these component experiences exist. This dynamic, deepening experience appears to be dependent on the recurrent processing (Kravitz et al., 2013).

To conclude, studies that have found evidence for fabrication have usually been designed to provide support for fabrication and lack of self-understanding, by forcing the participants to justify their preferences in conditions where they did not have access to their mental states that determined their preferences. When the emphasis has been shifted from justification to description of the subjective experience, the tendency to fabricate decreases significantly. This has rather increased participants' self-understanding and made them aware of the manipulations made by the experimenters. The issue is still mostly unsettled and requires further research.

1.4.3 WHEN VERBALIZATION DISTRACTS AND WHEN IT BENEFITS JUDGMENTS AND DECISIONS?

When there is a need to justify judgments and decisions that are difficult to explain, it may not only evoke fabrication, but may also make individuals uncertain about their earlier preferences and render their JDM behavior inconsistent (McGlone et al., 2005; Wilson & Schooler, 1991; Yamada, 2009). This alienation may occur due to a lack of vocabulary or of access to the factors that determine these preferences. As a consequence, participants change their preferences to ones that are easier to explain. Another way to explain this impact of reasoning on decision making is based on the assumption that preferences are based on subjective experience that result from rapid, automatic, unconscious and non-verbal processes. Reasoning, on the other hand, relies on conscious thought, which may not access the process behind subjective experience, thus replacing the originally intuitive process with conscious reasoning (Baumeister et al., 2011). Many authors, in fact, suggest that this is something that conscious thought should normally do, namely re-evaluate the intuitive responses, and correct them when needed with a normative response (Kahneman, 2003; Toplak, West, & Stanovich, 2011). This additional reflection can lead individuals to reject the initial preference and replace it with an alternative which has a socially sound explanation (Tilmann Betsch, 2011; Simonson & Nowlis, 2000). This is generally how culture and social environment affect our judgments and decisions (Baumeister & Masicampo, 2010; Briley et al., 2010). In addition to socially accountable situations, conscious reasoning is usually activated by conflicts (Shafir et al., 1993), or novel situations (Verplanken et al., 1997), when automatic processes fail to provide an unambiguous action plan.

Recently, some authors have claimed that people should not always reject their intuitive impressions. Experts, for example, can have sophisticated intuitions which rely on the identification of the situation and the activation of the solution that is related to that specific situation (Lipshitz et al., 2001). Conscious reasoning is also assumed to suffer from the capacity limitations of the working memory and serial processing, which can lead to a maladaptive weighting of the attributes (Dijksterhuis & Nordgren, 2006; Levine et al., 1996) or generally simpler strategies (Glöckner & Betsch, 2008b). Levine, Halberstadt and Goldstone (1996) suggest that conscious reasoning leads to the impaired weighting of attributes because only a subset of attributes can be taken into account due to the limitations of conscious thinking. This leads to inconsistent weighting, or a *dilution effect* (Nisbett, Ukier, & Lemley, 1981), where the more important attributes are given too little weight, and the less important attributes too much weight.

The above accounts, however, concern situations where all relevant information about the decision is immediately available: intuitive thought is unable to seek information that is missing from the perception of an initial stimulus that evokes the intuitive response (Hogarth, 2005; Kahneman, 2003). As mentioned previously, information integration in decision making can occur automatically; an information search may sometimes require effortful search (Dijksterhuis & Nordgren, 2006; Glöckner & Betsch, 2008a). This voluntary acquisition of information ensures that all the relevant information has been presented in the phenomenal consciousness so it can be integrated into otherwise automatic decision processes. Conscious thinking is therefore required to ensure that all relevant aspects of decision have been considered and the quality and quantity of the information is adequate to come to a conclusion (Evans & Stanovich, 2013). If evidence does not yet warrant a decision, the individual can seek additional information. The folk psychological idea of conscious deliberation probably refers to this aspect of becoming aware of all the relevant aspects of a decision, not to the voluntary strategies of finding the best alternative.

There are also instances where subjective experience does not provide a clear answer to the question of which of the alternatives is the best. In novel settings (Aarts, Verplanken, & van Knippenberg, 1998) or in conflict situations (Shafir et al., 1993), people may resort to conscious thinking to solve a decision problem. In these cases, an individual must first determine which attribute is preferable before preference among alternatives can be determined. In other words, the individual's attention is focused on details (attributes) instead of wholes (alternatives). This appears to be an automatic reaction in situations where fluent processing is somehow hindered (Alter et al., 2007; Botvinick, 2007). The focus on details probably helps one to bring more relevant information into consciousness, so that a certain conclusion can be reached. It has been suggested that the function of consciousness is to present information about these kinds of conflicts in particular (Morsella et al., 2016). Subsequently, people should be able to introspect reliably these kinds of goal conflicts (Berger, Dennehy, Bargh, & Morsella, 2016).

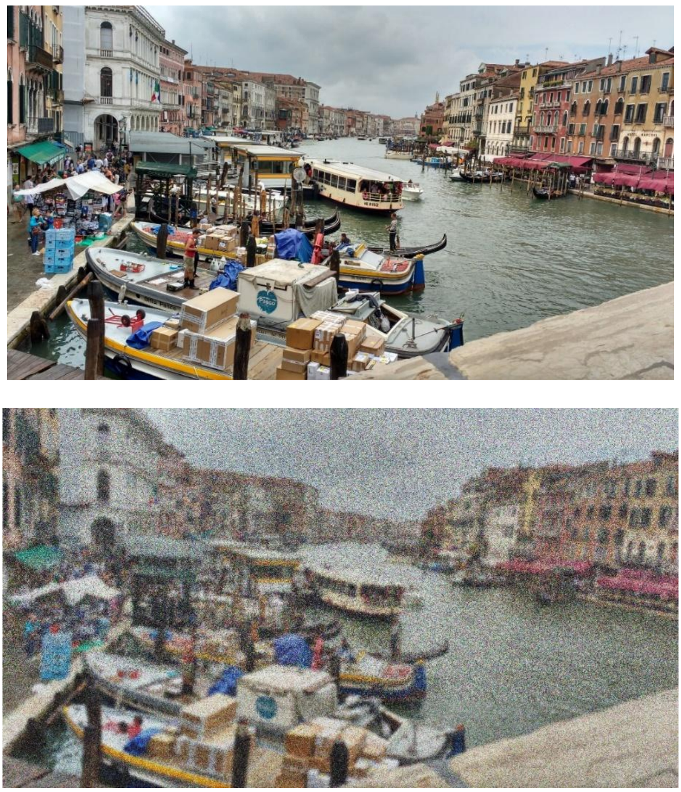


Figure 3 An example of an easy, non-conflicting decision.

Consider Figure 3, which contains two images of different image quality. The preference in this case is rather easy to obtain, as this case does not require tradeoffs between alternatives, and we can make this decision quite automatically; we ‘see’ instantly that one image is better than the other. However, if we are required to make a choice between images in Figure 4, the task is much more difficult, as it requires a trade-off between a noisy and a blurry image. In this case, some conscious deliberation is needed to come up with a resolution by focusing on the attributes. This kind of decision is somewhat uncomfortable, as it involves conflict between two attributes and therefore requires effortful resolution.

Conflicts can also inform an individual that the task is somewhat novel. If one is repeatedly required to make these kinds of decisions, the process will become more automatic, and the accompanying conflict will be reduced, as the individual learns the subjective importance of the attributes and learns to weight them accordingly (Hoeffler & Ariely, 1999). This development is manifested in more stable preferences. The more experience people have with different attributes in a certain context, the more expertise they acquire within that context (Hoeffler et al., 2013). As the effort in these novel tasks has been associated with better learning results, it appears plausible that effortful conscious thinking could benefit learning in these tasks. Also, if conscious reasoning is required in these kinds of novel tasks, individuals should be able to verbalize the reasons for their choices, at least if they have the vocabulary to do so.

To conclude, explaining in JDM tasks appears to interfere in tasks where subjective experience is difficult to describe, one is unable to access the reasons for one’s preferences, or the preference is formed automatically. How far can these laboratory findings be generalized? Is it possible to avoid these unwanted effects by asking participants to concentrate on their experiences instead of justifying their decisions and hence reducing the social pressure? There is also much evidence from tasks which benefit from the use of conscious cognition (Fox et al., 2011; Hamilton, Hong, & Chernev, 2007; Hammond et al., 1987; McMackin & Slovic, 2000; Sieck & Yates, 1997). Common to these tasks is the analytic approach where separate pieces of information are either sought or analyzed, the novel or unusual nature of the task, or where effortful information search is required.

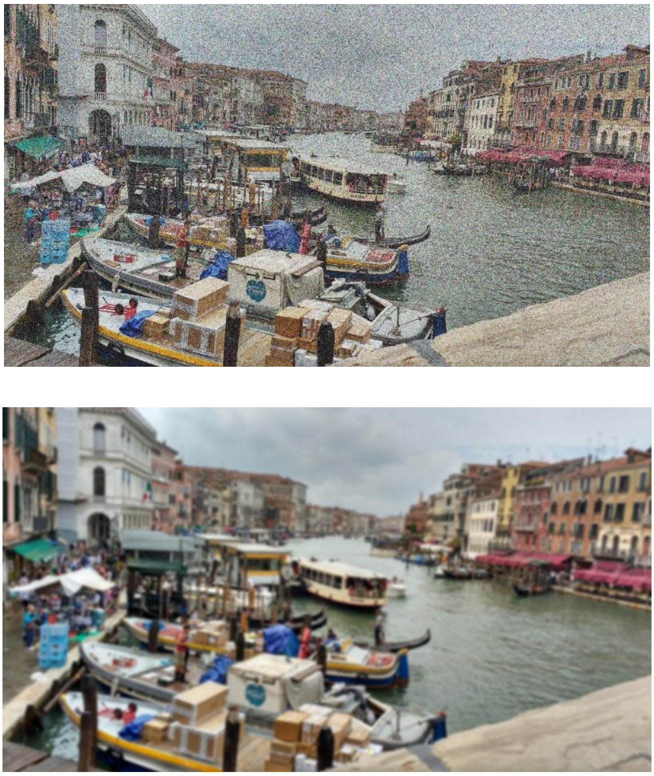


Figure 4 An example of conflicting decision. An individual required to make a trade-off between blur and noise must determine the subjective importance of blur and noise before making a decision.

2 PURPOSE OF THE RESEARCH

The principal purpose of this dissertation is to respond to three claims that have often made in academic psychology about the possibility of using subjective explanations as data in the study of preferences. These claims concern 1) conscious accessibility to the JDM processes, 2) fabrication when research participants are asked to explain their judgments and decisions, and 3) the possibility that explaining would interfere with JDM processes. The assumption behind this dissertation is that not all explanations are alike: justification of choices and judgments may indeed in some cases mean detachment from one's authentic subjective experiences. This may lead to fabrication and to distraction from the original judgment process. This however appears to be a very context-dependent issue. There is some evidence that focusing on subjective experiences can prevent these unwanted effects of explanations, and explaining in some cases may even deepen the experience and focus attention on the most relevant things, therefore benefiting the judgments.

The first claim suggests that people rely on similar causal theories when they explain their own judgments and the judgments of others (Dennett, 1991; Gazzaniga, 1989; Nisbett & Wilson, 1977). This suggests that their explanations should not produce any new information. Study I aimed to test specifically whether a method relying on subjective explanations such as the IBQ method can produce and useful information. Similarly, Study I aimed to test the possibility of fabrication (claim 2), by analyzing the relations between judgments, descriptions of experience and objective stimuli. If the link between subjective attributes and quality ratings or images is missing, then it should be the first sign of significant problems with the IBQ approach. Otherwise, if we find the link, it means that the explanations provide at least a good understanding about the reasons that determine the quality ratings and thus useful information for image quality engineers.

Study II aimed to test whether explaining interferes with judgment and decision making in a visual, high image quality context (Claim 3). In this study quality judgments that were explained were compared with judgment without explanations. A popular hypothesis suggests that increased deliberation would diminish the preference differences between alternatives (dilution effect; Nisbett et al., 1981) as the attention is directed towards the less important attributes (Wilson & Schooler, 1991). If explaining one's choices does not have an effect on judgments and decisions, it can diminish the doubt that self-reports on the reasons for choices would somehow interfere with JDM processes. If the participant's performance, contrary to earlier findings, benefits from explaining, it suggests that the IBQ method would be particularly useful in tasks where differences are small, as in high image quality.

Study III examined the relevance of reason fabrication (Claim 2), when participants are asked to explain their choices in an image quality evaluation task. In Study I, fabrication is studied by analyzing the association between the alternatives and subjective attributes. In Study III, the coherency of the explanations in relation to the objective parameters of the alternatives is compared with quantitative measures that describe the quality of the decision-making process. If participants fabricate their explanations, there should be no link between the explanations and the choices.

The purpose of Study IV was to clarify the role of conscious thinking in learning. It tested the possibility that the facilitative effect of explaining in the image quality task would be a result of the processing shift towards more conscious thinking, which would benefit novel tasks in particular. This study analyzed the effect of reasoning on learning in decision-making tasks involving image quality evaluation. As the effect of explaining has been attributed to its maladaptive influence on attribute weighting and preference stability, this study specifically concentrated on these issues.

3 METHODS

3.1 PARTICIPANTS

Participants in all studies were university students, recruited from university e-mail lists, with a few exceptions. Due to the demographics of the university student population, participants were mostly young adults and the number of females was larger (Table 1). Participants reported having normal vision; in Studies I and IV their vision was also tested.

Table 1. *Participants in different studies.*

Study		Participants	Males
Study I	Experiment 1	30	6
	Experiment 2	31	9
Studies II-III		59	8
Study IV	Experiment 1	103	23
	Experiment 2	63	8
	Experiment 3	63	15
Total		349	

3.2 STIMULI

In all studies, stimuli consisted of natural image contents (photographs) that were processed, resulting in a set of images with varying image quality. Only images with the same content were compared against each other. In Study I, the stimulus photographs were printed (size 10 cm * 13 cm). In Studies II-IV, stimulus images were presented on color-calibrated 24.1 inch Eizo ColorEdge CG241W displays. The resolution of the images was 1920 * 1200 pixels.

3.2.1 STIMULI IN STUDY I

In Study I, the stimuli were created by processing photographic contents in image signal processors (ISP), which produce the final digital photograph from the RAW format image that is created by the camera sensor. In addition to creating the final image from the pixels representing different colors (blue, green and red), the purpose of the ISP is to optimize image quality by applying, for example, noise reduction, sharpening, color, and lightness adjustments in the raw image data (Peltoketo, 2016). Seventeen image contents were used in two experiments. Six ISPs were used in Experiment 1 and eight ISPs in Experiment 2.

3.2.2 STIMULI IN STUDIES II-IV

In Studies II-IV, the images were generated by manipulating four quality parameters: Blur, noise, color and lightness. The selection of these parameters was based on the data from Study I and other similar studies; they represent the most important dimensions of image quality in this context, when importance is defined as the frequency with which the attribute is mentioned

In Studies II and III, three image contents (*Town*, *Children*, *Party*) were used. The quality of images was manipulated factorially by adding blur or noise, or by changing the white point or luminance level of the image. White point manipulation changes the color temperature of the image, so it becomes either more reddish or blueish. When there were four manipulations, the number of samples for each content was 2 * 2 * 2 * 2 = 16. In Study IV, only Town and Party contents were used. Also the samples where three or four attributes were manipulated were left out, so that only 11 samples for both contents were used in the study.

Figure 5 Examples of image processing in Studies II-IV. The image at top left has changes in color temperature; the top right image has added noise; the bottom left image is blurred and the bottom right image has increased luminance.

3.3 EXPERIMENTAL DESIGN

In all studies, participants were asked to evaluate image quality. In Study I, image quality estimation was made by first ranking and then rating the images according to their quality. In Studies II-IV the evaluation was made using the paired comparison method. In order to investigate experimentally the effect of explaining on decisions, we compared blocks requiring explanations with blocks that did not require explanations. Each block consisted of a large number of pair-wise choice trials, where the participant was asked to make a decision between two images with small quality differences.

3.4 DATA ANALYSIS

3.4.1 QUANTIFICATION OF CHOICE BEHAVIOR

In paired comparison trials (Studies II-IV), distribution of choices is analyzed as logits, which are based on the choice probabilities of alternatives (formula 1, where p and 1-p represent the choice probabilities of two alternatives in a pair).

(1) $$\text{logit}(p) = \ln [p / (1 - p)]$$

Logit transform linearizes the probability values. The sums of logits are used for comparing the preference differences between conditions in Study II, the reliability of participants in Studies II and IV and the weighting of the attributes in Study IV.

The number of intransitive choices are counted to measure participants' preference stability in Studies III-IV. Intransitive choices are patterns $A \succ B$, $B \succ C$, $C \succ A$, where A, B and C are different alternatives and $\succ$ indicates preference in paired choice trials. To normalize the data, logarithm transformation is applied to the number of intransitive choices.

3.4.2 ANALYSIS OF EXPLANATIONS

3.4.2.1 Qualitative analysis in Study I

The grounded theory approach (Strauss & Corbin, 1998) was applied in the analysis of the JDM attributes. This qualitative analysis method is based on the idea that theory should be formed on the basis of empirical, qualitative data, and on the researcher's conceptualization of the data that emerges gradually during the analysis, when the researcher acquires understanding about the relations between the concepts in the data. Grounded theory played a larger role when the IBQ methodology was created (e.g. Eklund, 2001; Raitisto, 2001; Salonen, 2001). The coding scheme used in Study I was a somewhat reduced and simplified form of grounded theory. It was only used for finding the relevant concepts that the participants used, so it lacked the theory building part of the original approach.

The first phase of this approach was based on *open coding*, where the researcher goes through the text material and the explanations for ratings by gathering themes that appear relevant. These themes are marked with codes, such as “sharp,” “soft,” “artistic” or “grainy.” The text material consists of free descriptions, consisting mostly of lists of attributes, but also short sentences. Atlas.ti software (Muhr, 2004) was used for coding. Following the grounded theory philosophy, the themes emerged from the text, not from existing theory (hence ‘grounded theory’, as the theory in this case is grounded on data).

In the second phase, the codes created in the first phase are merged into concepts. Participants can use different words to describe similar experiences: for example, they can use words like “fuzzy”, “unsharp” or “blurry” for the same experience of lacking sharpness. As the purpose of the experiment is not to study words but the participants’ actual experiences, the codes that appear to describe the same experience are merged into the same concept. This phase is based on the researchers’ subjective interpretation of the meanings behind the participants’ explanations. Therefore some kind of inter-coder reliability check should be conducted to ensure that people share a similar understanding about the concepts in a certain context. In the case of image quality, the majority of the concepts appear to have excellent or good inter-coder reliability (Radun et al., 2008).

3.4.2.2 Quantitative analysis in Study III

Contrary to the qualitative analysis of Study I, the second phase of the qualitative analysis was not done in Study III; the coding of the explanation data in this study was done without making any interpretations about the meanings of the attributes, so only obvious synonyms (e.g. “not sharp” and “unsharp”) were merged into the same code. For example, attributes such as blurry and unsharp were kept separate in order to respect the personal use of attributes individuals use and to diminish the researcher’s influence on the interpretation of the data.

For each attribute, objective counterpart(s) were sought by examining the co-occurrences between attributes and objective differences between the stimuli. This was done participant-wise. The objective parameter(s) with the highest probability of co-occurrence with a certain attribute were selected as a corresponding objective counterpart. Further analyses were made with these subjective attribute – objective parameter pairs.

Two measures were developed to describe the participants’ correspondence between explanations and objective differences: *consistency* and *predictability*. Consistency referred to the probability that the participant uses the attributes with the corresponding objective parameters. The predictability, on the other hand, is the Bayesian probability of a certain attribute being present in participants’ explanations with a certain configuration of objective parameters:

(2) $P(subj \mid obj) = [P(obj \mid subj) * P(subj)] / P(obj)$

Where P (subj | obj) is the predictability value for each attribute, P (obj | subj) is the probability of certain objective parameters when a corresponding subjective attribute is mentioned (that is, consistency), P (subj) is the probability of an attribute and P (obj) is the probability of the objective parameter.

The final values used for describing the participants' performance in the task were derived from weighted mean predictability and consistency values averaged over all attributes. The weight was determined by the attribute's frequency.

4 EXPERIMENTS AND RESULTS

4.1 STUDY I: SUBJECTIVE QUALITY EXPERIENCE OF IMAGES PROCESSED WITH DIFFERENT IMAGE SIGNAL PROCESSORS

4.1.1 PROCEDURE

After vision tests, participants were asked to rank the images according to their quality. Ranking was done by categorizing images into 11 classes, representing the numbers from 0 to 10: all the samples of each image content were given to the participant, who was first asked to choose the lowest quality and highest quality sample in that content. Number 0 represented the lowest quality sample in the set and 10 the best sample. After this, the rest of the samples were divided into categories representing the numbers 0-10. Participants were asked to use all categories, but they could also put more than one image into a category. The order of the contents was randomized. After the ranking, participants were asked to describe the quality aspects of each picture in their own words.

4.1.2 RESULTS

Attribute frequencies suggest that color balance, sharpness, luminance level, graininess and naturalness are the most important aspects of image quality in this context, in this order (Figure 6).

In order to find the dimensions of quality experience that differentiate different ISPs from each other, correspondence analysis (CA) was performed on the attribute-ISP cross-tabulation collected from both experiments 1 and 2. The number of attributes in the analysis was 20 and the number of ISPs 14, although one ISP was present twice as it was used in both experiments. The three most explanatory dimensions were taken into further analysis. The most important dimension, accounting for 45.8% of the variance, was the color distortion dimension, which separated the images with natural images from images which had shifted colors (Figure 7). The second most explanatory dimension separated the grainy images from dark images, accounting for 26.1% of the variance. Finally, the third dimension, accounting for 17.7% of the variance, separated sharp from unsharp images.

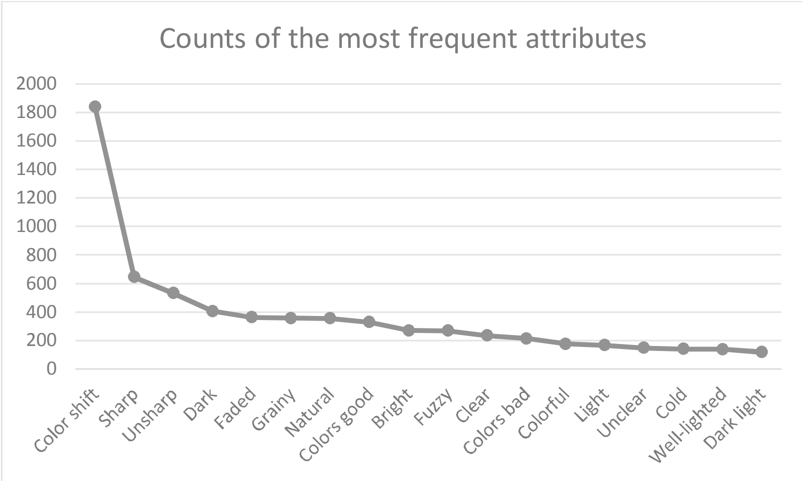
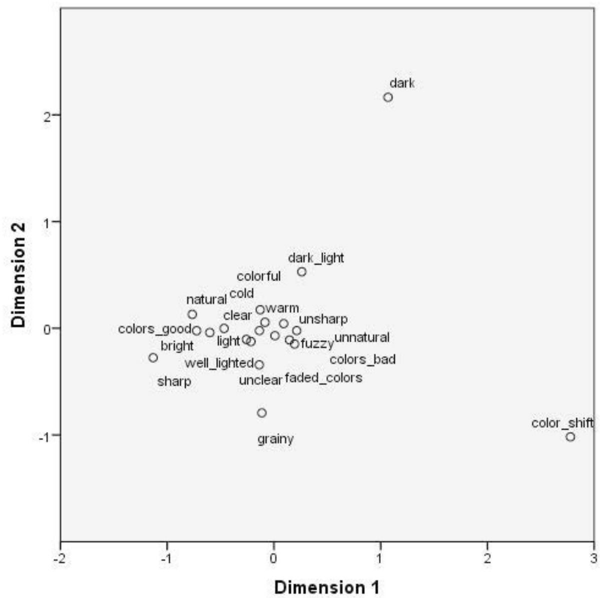


Figure 6 Frequencies of different attributes in Study I.

When information about the attribute dimensions is combined with information about the average ratings of the ISPs (Figure 8), the picture becomes clearer: it appears that the color shift dimension is monotonically related to quality ratings, so that images from ISPs lacking this color shift are experienced as more natural and therefore of better quality. In the two other dimensions, the optimal experience exists in the middle; the farther the ISP is located from this middle point, the worse ratings it receives. When dimension 1 is quite directly related to quality ratings in all ISPs, dimensions 2 and 3 appear to differentiate between the best ISPs and the ISPs that are rated between the worst and the best.



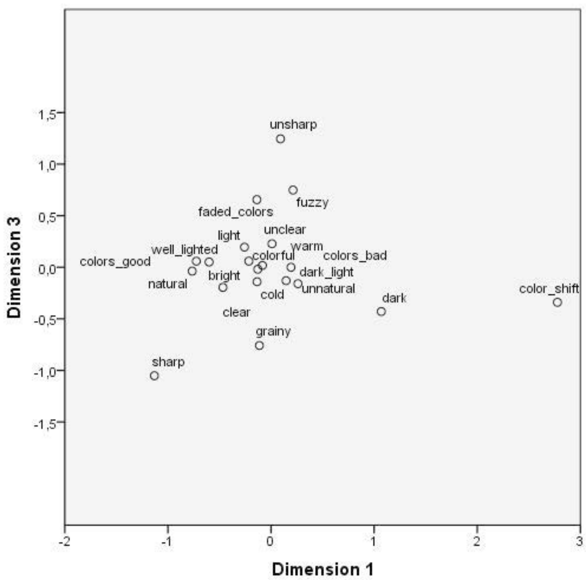


Figure 7 Perceptual map provided by the correspondence analysis performed on the attribute-ISP cross-tabulation. Dimension 1 differentiates the ISPs with good color reproduction from ISPs with color shift. Dimension 2 differentiates ISPs producing dark images from ISPs producing grainy images. Dimension 3 differentiates sharp ISPs from unsharp ISPs

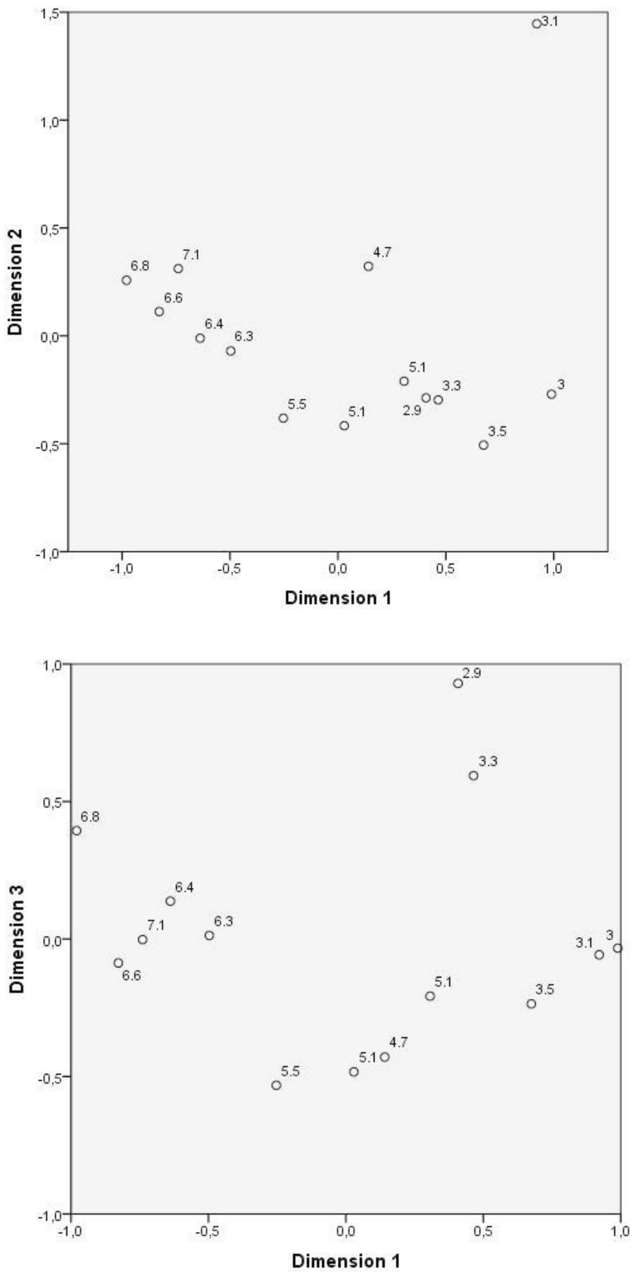


Figure 8 Mean quality ratings for ISPs appear to be monotonically related to dimension 1. Dimensions 2 and 3 have optimum levels that are located near the origin.

4.1.3 CONCLUSIONS FROM STUDY I

Study I suggests that participants' free verbal descriptions provide rich qualitative data why certain ISPs fail to produce good-quality images. By enhancing color reproduction (dimension 1), much improvement could be done in image quality. After this, engineers should optimize the balance between graininess and darkness (dimension 2): when images are shot in low lighting conditions, the signal-to-noise ratio tends to be low and the amplification of the signal may decrease darkness but increase noise (that is, graininess). The resulting noise, on the other hand, can be reduced by slightly averaging the pixels in the image (dimension 3); the resulting blur, however, can reduce the quality more than it is increased by reducing the amount of noise.

The purpose of the CA in this case is not to provide a picture of the general image quality dimensions that participants experience. Instead, it describes the dimensions of experience that differentiate between ISPs in this set of ISPs and contents. "Sharp" and "grainy," for example, are in this case located quite near to each other in the perceptual map provided by the CA, which means that ISPs that produce sharp images in certain contents produce noisy images in others, due to the noise reduction technique described. A similar optimization problem also exists with the luminance level and noise. ISP is a system in which one parameter affects other parameters, often with unexpected results.

The results therefore illustrate the important applied decision problem, which is the question of multidimensional optimization. This means that the best choice requires trade-offs between attributes. The purpose of Study I was to show that free descriptions provide data that is consistently related both to the judgments and the objective properties of the judged objects in a context that is multidimensional and systemic. As previously shown (Leisti et al., 2009; Radun et al., 2008), consumers appear to share a common vocabulary about image quality, which they use when describing differences among images. This vocabulary relates to a low-dimensional conceptual space that describes the differences between the subjective experiences concerning image quality and the stimuli being evaluated.

Although the IBQ method is not specifically designed to provide information about judgment strategies, the results of the CA suggest that people appear to use less criteria when the quality is low, but when it gets better more criteria are taken into account. The attribute named "color shift" stands alone in the dimension differentiating between good and bad ISPs, which suggests that the worst quality images are mostly experienced as having distorted colors. To some degree, this also applies to the attributes "dark" and "grainy." This can be interpreted so that when certain weakness in the image is salient, the image is immediately experienced as weak in terms of quality and it will not be further examined. The decision is easily made, when single diagnostic criterion is instantly accessible, supporting a simple intuitive approach to the decision. However, when the quality gets better, the participants take more attributes into consideration. In these cases, conscious thought may be activated to find out solutions for the tradeoffs between attributes.

4.2 STUDY II: EFFECT OF EXPLAINING ON INFORMATION USE IN VISUAL DECISION MAKING

Study I analyzed the correspondence between the free verbal description of quality experience between products and judgments. In Study II, we examined how explaining affected the strength of preferences across all participants, and participants' reliability of choices in our task. For the purposes of this study, we developed an experimental methodology to study high quality image quality where multiattribute JDM would be relevant. Therefore we designed a pair-wise choice task, with alternatives with separable, non-salient, easily verbalized visual attributes. Separability means that visual dimensions can be seen separately, unlike, for example, the dimensions of color (Garner & Felfoldy, 1970): the mix of green and red appears as yellow; one cannot separate this mix as green and yellow. Non-salient attributes are attributes that are not instantly seen at the stimulus, but they require some voluntary search to be detected. The assumption of easy verbalization relies on our previous studies, where sharpness, graininess, lightness and color were among the most frequent attributes mentioned by the research participants (Leisti, Radun, Virtanen, Halonen, & Nyman, 2009; Radun et al., 2010).

Our experiment consisted of 3 blocks with 120 trials. The middle block was done with explanations, and the 2 other blocks were silent control blocks. The preference difference was defined by first calculating the choice probabilities of alternatives in all pairs across participants and transforming these probabilities into logits. The mean preference differences of the pairs were then compared between the conditions using Friedman's ANOVA. In addition to preference polarization between alternatives, this measure also reflects the degree of consensus about which of the pairs is better.

Participants' reliability in this experiment was defined as how often the participant chose the same alternative when the differences were the same: four different manipulations existed (blur, noise, lightness, color), and for each manipulation there were eight image pairs where the only difference was in the manipulation in question. The logit values of the choice probabilities from these pairs were summed for each participant and condition as a measure of reliability in each condition.

4.2.1 PROCEDURE

Participants were asked to evaluate image quality in paired comparison setting in conditions that either required explanations for choices or did not. One participant completed three blocks: the first was silent (i.e. did not require explanations), the second required explanations and the third was again silent. In each block, participants made 120 paired, forced choices between different versions of the same image content. In other words, participants went through all the pair combinations of sixteen samples of each content in random order. Contents for different blocks were randomized and counter-balanced between participants.

4.2.2 RESULTS

Explaining polarized the preference differences between the alternatives (Friedman's ANOVA: $\chi^2(2) = 72.117$, $p < .001$): the differences between pairs were larger ($M = 1.11$; $SD = 1.22$) in conditions requiring explanations than in both the first silent ($M = .56$; $SD = .86$; $Z = -10.62$, $p < .001$), and the second silent block ($M = .57$; $SD = .74$; $Z = 11.22$, $p < .001$). No difference was found between two silent conditions ($Z = -.571$; $p < .58$).

The experimental condition had a significant effect on the participants' reliability as well ($F(2, 106) = 22.89$; $p < .001$; Figure 9): they were more reliable in their choices when they were asked to explain their choices than in two silent conditions ($F(1, 53) = 25.28$; $p < .001$; and $F(1, 53) = 38.16$; $p < .001$).

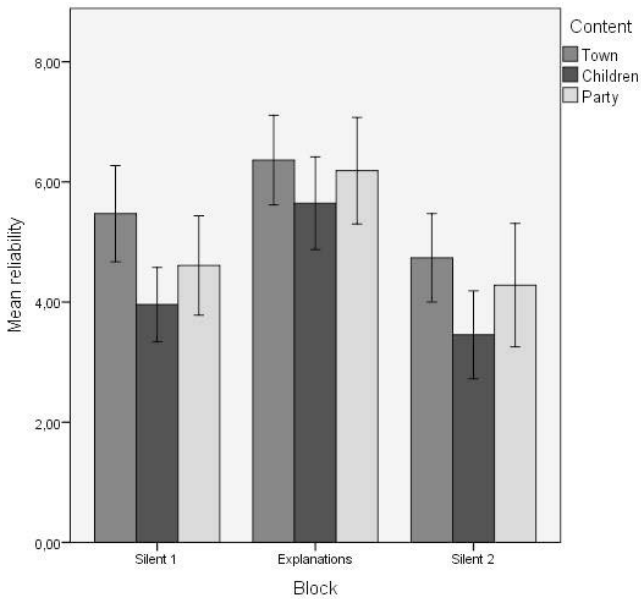


Figure 9 Reliability in different blocks.

In addition to reliability, the reason for this beneficial effect of explaining was sought from the participants' choice behavior. We examined how much their decisions resembled choices based on the logistic regression model, which would in this case represent the compensatory weight additive (WADD) strategy, and would take all available information into account. The similarity with the logistic model was calculated from the area under the ROC curve (AOR). We found that condition, again, had significant effect on AORs ($F(2, 106) = 1.45$; $p < .001$.). The explanation condition differed from both silent conditions ($t(58) = 3.13$; $p = .003$; and $t(58) = 4.26$; $p < .001$). This suggests that more information was taken into account when determining the choices in the condition that required participants to explain their choices. This appears to be related to better reliability ($r = .58$; $p < .001$; Figure 10).

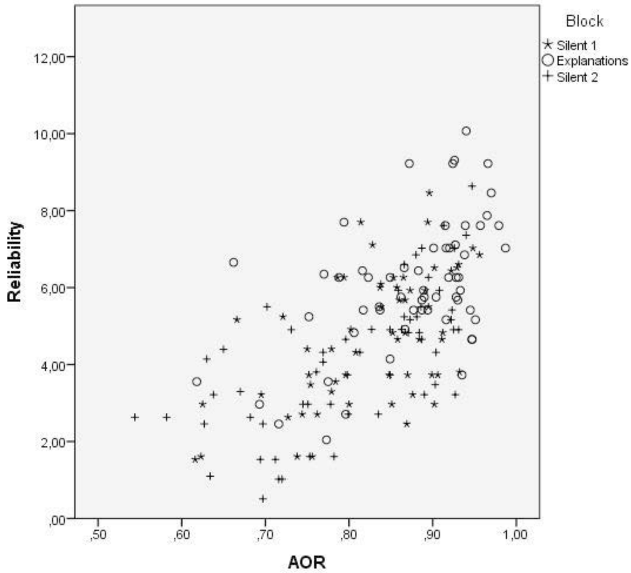


Figure 10 Area under the ROC curve plotted as a function of reliability.

4.2.3 CONCLUSIONS FROM STUDY II

It has been suggested that judgments and decisions that are based on perceptual experiences are prone to interference of verbalization (McGlone et al., 2005; Wilson et al., 1993; Yamada, 2009), either due to lack of vocabulary, or due to a processing change from a more automatic to a more conscious mode. That explaining facilitated choices in this perceptual JDM task in this study contradicts these assumptions and suggests that explaining has a beneficial effect on the evaluation of high quality images. This was a novel result, and also an unexpected finding as the consensus about the distracting effect of verbalization in perceptual JDM tasks has been so strong, independent of the school of thought (Chin & Schooler, 2008; Ericsson & Simon, 1980; Wilson & Schooler, 1991).

Study II showed that conscious thought processes and perceptual processes function in interaction with each other and that explaining appears to facilitate information acquisition: participants were both more reliable and used strategies that relied on more comprehensive information use than when they were not required to explain their choices. The results support the idea that conscious thought benefits information acquisition in particular, as well as the assumption that accountability requires participants to use more effort in considering more information in their decisions.

4.3 STUDY III: QUALITY OF EXPLANATIONS AND STABILITY OF PREFERENCE

In Study III, we wanted to examine the contents of the explanations quantitatively to understand how they are related to the participants' behavior. The target of investigation was the association between the participants' preference stability and the predictability of the explanations. A strong association between these measures suggests that they reflect a common underlying thought process, which determines the participants' decisions. This would inform about the possibility of fabrication in similar tasks. In addition to this general tendency, we wanted to understand individual differences in the response to the requirement to explain one's decisions. The hypothesis was that participants who have problems approaching the task by means of conscious thought should perform better in the silent condition, whereas participants who can successfully perform conscious thinking in the task should benefit from explaining. This would explain the results about the different effect of explaining in different tasks.

We examined the participants' preference stability by calculating the number of intransitive choices. In the simplest case, intransitivity occurs with three alternatives A, B and C, when A is preferred over B, B is preferred over C, and C is preferred over A. The explanations were quantified by using measures for predictability and consistency. Predictability is the Bayesian probability that an explanation can be predicted from the objective differences between alternatives. Consistency, on the other hand, is the proportion of the explanations presented consistently with a corresponding objective difference.

4.3.1 DATA

Explanation and choice data from Study II was re-analyzed in this study.

4.3.2 RESULTS OF STUDY III

The condition had significant effect on the log-transformed number of intransitive choices ($F(2, 106) = 1.45$; $p < .001$. $\eta 2 = .17$). The requirement to explain choices decreased intransitivity in comparison with the first silent (t(58) = 3.62; p = .001; d = .29), and last silent block (t(58) = 4.03; p = .001.; d = .44). In this case, reasoning appears to make the participants' preferences more stable, which is contrary to several studies on the subject and is in line with the results of Study II concerning the more comprehensive use of information when the decisions were asked to be explained.

The reason for this change in performance was sought from the explanations of the participants. When we examined the relation between the quantitative measures describing the explanations and preference stability, we found that predictability of explanations is negatively associated with intransitivity, but only in the condition which required explaining ($B = -2.46$; $p < .001$; $R^2 = .34$); in silent conditions, the participants' predictability was not related to their performance (first block: $B = .20$; $p > .05$; $R^2 = .09$ second block: $B = .09$; $p > .05$; $R^2 = .04$). This supports the assumption that explaining causes a shift in processing from an intuitive to a more conscious mode.

On an individual level, the ability to create predictable explanations appears to explain the change in the number of intransitive choices from a silent condition to a condition requiring explanations ($B = -2.65$; $p < .001$; $R^2 = .19$; Figure 11) and vice versa ($B = 2.55$; $p < .01$; $R^2 = .20$). In other words, if individuals create good explanations, they will benefit from explaining, whereas the situation is the opposite with those who cannot create good explanations.

Concerning the role of consistency, we found that it was associated with the reliability of the choices ($B = 8.59$; $p < .001$; $R^2 = .24$), but not with the number of intransitive choices. This only applied to the explanation conditions; the association was non-significant in the silent conditions.

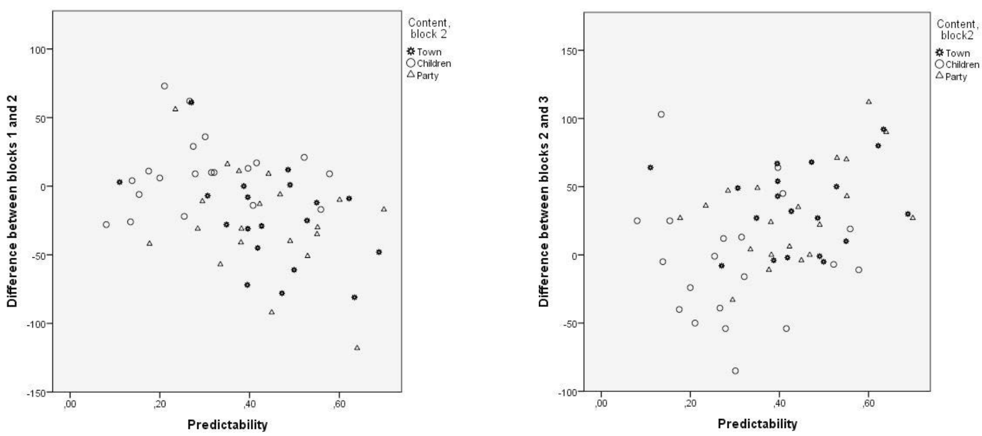


Figure 11 Difference in the log-transformed number of intransitive choices plotted against the predictability of the explanations.

4.3.3 CONCLUSIONS FROM STUDY III

Study III indicates a clear link between conscious thoughts and the participants' performance. The more coherent explanations the participant can create, the more coherent is the participant's behavior, suggesting that explanations for choices reflect the underlying process that also determines the participant's choices. However, conclusions cannot be made about the participants' performance in the silent condition in the explanations: the participants' response to the requirement to explain their choices appears to be dependent on personal and context factors. These factors determine whether the individual benefits from conscious thought in these cases or whether conscious thinking has a distracting effect on the judgment processes. The participants that could create more predictable explanations could improve their stability in the second block of the experiment.

We assumed that the participants' reliability would be related to enhanced carefulness as well as to the consistency of the explanations. We found that consistency indeed is related to better reliability, but not to more stable preferences. This dissociation suggests that stability of preferences in this case results from the processing shift, not from carefulness in information acquisition.

4.4 STUDY IV: THE EFFECT OF EXPLAINING ON LEARNING IN VISUAL DECISION MAKING

In our earlier experiments, we controlled the effect of learning by placing it between the silent blocks. This experimental setting, however, does not take into account that, at the end of the experiment, fatigue may cancel the effect of learning. The better performance in the middle explaining block may therefore be caused by learning, not by explaining, and this learning effect could then be cancelled by fatigue in the last, third block. We therefore made three further experiments to examine this possible learning effect. In this study, we also wanted to generally examine the change of weights and preference stability over several minor decisions, both when decisions are explained and when they are not explained. This should increase understanding about the role of conscious thought in learning in JDM tasks.

Preference stability results from learning, but it is also influenced by the requirement to justify one's preferences. Additionally, attribute weights are affected by these factors, too, and it is not known whether these effects interact with each other. We measured both preference stability and the weights both between blocks, where different image contents were evaluated, and within blocks, where the target of evaluation stayed the same. All experiments had 55 trials in two blocks. To examine the effect of learning within each block, we divided each block into five phases with 11 trials. The explanation block was randomly either in the first or in the second block of the first experiment. Experiment 2A required explaining in both blocks and Experiment 2B was completely silent. Preference stability was measured by calculating the number of intransitive choices in paired comparisons. The weights of the attributes were estimated by calculating the probability of how often the participants chose the alternative with a certain attribute.

4.4.1 EXPERIMENT 1

4.4.1.1 Procedure

Each experiment in this study contained two blocks, with different image content, which were randomized and counter-balanced between participants. In each block, participants made 55 paired choices, consisting of all pair combinations of 11 stimuli. In Experiment 1, one block was silent and the other required explanations. The order of these conditions was varied between two experimental groups. In Experiment 2, participants explained their choices in both blocks. Experiment 3 was similar to Experiment 2, except that both blocks were silent

4.4.1.2 Experiment 1: Results

Only the interaction between the condition (explanations vs. silent) and the order of the conditions was significant ($F(1, 92) = 7.97$; $p = .006$; partial $\eta^2 = .08$). Therefore both explanations and learning improved the participants' preference stability. When explanations were required in the first block, the effects of learning and explanations neutralized each other, as the first block benefitted from explaining and the second block from learning ($F(1, 46) = .50$; $p = .483$). In the group in which the explanations were required in the second block, the participants benefitted from both learning and explaining ($F(1, 46) = 12.02$; $p = .001$; partial $\eta^2 = .21$). Learning was then examined by dividing each block into five phases. The number of intransitive choices was found to decrease by phases ($F(4, 96) = 8.73$; $p < .001$; partial $\eta^2 = .28$). The participants' preference stability thus improved when they learned to execute the task.

This increasing stability was accompanied by increasing attribute weights ($F(4, 368) = 2.75$; $p =.03$; partial $\eta^2 = .03$) and, to be more precise, only the weight of the most important attribute ($F(4, 368) = 11.89$; $p < .001$; partial $\eta^2 = .25$). Therefore it seems that preferences stabilize when participants become more certain about the importance of the attributes. Mediation analysis, however, did not give definite support for this assumption.

4.4.2 EXPERIMENTS 2A AND 2B

Experiments 2A and 2B aimed to isolate the effect of learning from explaining. Therefore participants in Experiment 2A explained their choices in both blocks, and in Experiment 2B both blocks were silent.

4.4.2.1 Experiment 2A: Results

Learning significantly decreased the number of intransitive choices when compared between the blocks (block 1: $M = 2.70$, $SD = .76$; block 2: $M = 2.34$, $SD = .90$; $F(1, 60) = 6.71$; $p = .012$; partial $\eta^2 = .10$). This was, again, accompanied by increasing attribute weights ($F(1, 58) = 8.69$; $p = .005$; partial $\eta^2 = .13$. This time, mediation analysis also confirmed that more consistent choices follow from more coherent attribute weighting: the difference of the most important attribute between blocks was significant ($t(61) = -2.298$; $p = .025$, and in the regression model ($R^2 = .62$) it predicted the log-transformed number of intransitive choices ($B = - .57$; $t(61) = -9.68$; $p < .001$). Within the blocks, the number of intransitive choices decreased ($F(4, 240) = 7.35$; $p < .001$; partial $\eta^2 = .11$) and the attribute weights increased ($F(4, 232) = 6.013$; $p < .001$; partial $\eta^2 = .09$; figure 7a).

4.4.2.2 Experiment 2B: Results

Experiment 2B was similar to Experiment 2, except that both blocks were silent. In this experiment, the block did not influence the number of intransitive choices ($F(1, 61) = 2.62$; $p = .11$; first block: $M = 2.72$, $SD = .82$; second block: $M = 2.51$, $SD = .80$). In other words, we did not find a significant effect for learning. This also applied to the weights of the attributes across the blocks. Even when blocks are divided into five phases, no significant learning was found within blocks, when measured as the log-transformed number of intransitive choices ($F(4, 244) = 2.21$; $p = .073$). This also applied to the attribute weights in general ($F(4, 240) = .41$; $p = .80$). However, the phase and the importance interacted ($F(12, 732) = 2.78$; $p = .001$; partial $\eta^2 = .04$; Figure 7b). This was due to the increasing weight of the most important attribute ($F(4, 244) = 6.67$; $p < .001$; partial $\eta^2 = .10$) and the decreasing weight of the second most important attribute ($F(4, 244) = 2.68$; $p = .032$; partial $\eta^2 = .04$). So, learning influenced the weights of the attributes but in different directions. Therefore, learning did not increase the choice consistency in the silent version of Experiment 2B, as it did in Experiment 2A that required explanations.

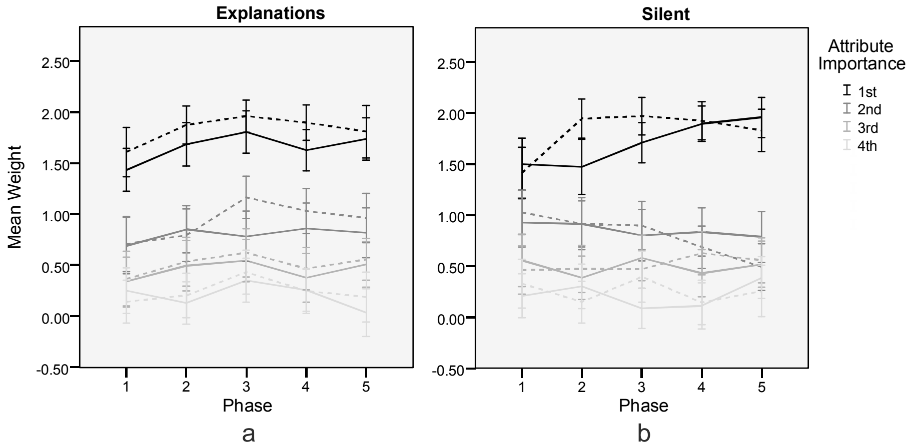


Figure 12 Development of the attribute weights according to their subjective importance in phases 1-5 of the experiment. Solid lines indicate the first block and dashed lines the second block of the experiment. Reprinted from Leisti & Häkkinen (2018).

4.4.3 CONCLUSIONS FROM STUDY IV

We found that better preference stability in the second block of our quality estimation task is indeed a consequence of learning. However, when the effect of learning is removed from the participants' performance, explaining still has a facilitating influence on participants' preference stability.

Additional analyses and experiments showed that, contrary to our earlier assumptions, facilitated preference stability occurred in the latter parts of the experiment, not in the early part, when the task was still novel to the participants. When participants started the experiment, they were probably using a rather conscious strategy, independent of whether they were asked to provide reasons for their choices. When the experiment continued, the participants who were not required to justify their decisions started to ignore less important attributes, whose weight started to decline. As a consequence, participants were unable to improve their preference stability. Participants who explained their choices through the experiments could improve their preference stability by increasing the overall weights of the attributes.

The results of Study IV suggest that conscious thinking appears to enhance the consistency of individuals in a larger time frame. Many previous findings about the influence of conscious reasoning on judgments have suggested that it may decrease the consistency of the participants, but these studies have used tasks that can be done rather automatically. Even more importantly, they have concerned only individual decisions, performed in isolation. The findings of Study IV suggest that explaining in a relatively novel task may improve learning and therefore enhance participants' consistency in the long run. Thus, following the assumptions presented in the introductory section, the role of conscious thought is to create temporal continuity in an individual's behavior and solve conflicts that emerge when there is no existing solution to JDM problems. The role of conscious thought is not to solve familiar decisions, because automatisms and routines exist for that purpose. Rather it can help to find and utilize additional information when the decision is somewhat unfamiliar or conflicting.

5 DISCUSSION

5.1 REVIEW OF THE KEY FINDINGS

The purpose of the four studies presented in this dissertation was to examine how explaining one's judgments and decisions affects JDM processes in the visual quality evaluation context, and how valid and useful data explanations can be provided to researchers. This research had therefore both applied and basic research motives: from the basic research perspective, examination of subjective explanations can clarify the role of self-reflection and awareness in JDM processes, as well as the social aspect of making one's decisions understandable to others. The applied perspective, on the other hand, aims to examine the usefulness and validity of the IBQ method in high image quality estimation.

The present studies were designed to respond to the three claims that are usually presented against the use of subjective explanations for judgments and decisions. These claims are, in a very simplified form: 1) people do not have conscious access to their JDM processes; 2) explanations about judgments and decisions are fabrications, not descriptions of real JDM processes; and 3) explaining one's judgments distracts these processes. In contrast, our assumption was that subjective explanations reflect the decision space for voluntary actions, and that people's deficient self-understanding relates to situations where perceptually oriented subjective experience and socially oriented conscious thought are in conflict and the participants have difficulties in providing socially credible explanations for their preferences. In these cases, people can detach themselves from their original experiences, which may end up in unwanted consequences, such as fabrication and interference with the JDM process. When subjective experience and conscious thought work in concert, however, the description of experience may even enrich and deepen the subjective experience, thus increasing the available information for judgments. This reflection can also increase self-understanding and coherence in judgments and decisions in the long run, ultimately leading to better learning.

The influential theory of stock-pile explanations (Claim 1; Nisbett & Wilson, 1977) suggests that people explain their judgments and decisions using the same processes they would use when explaining other people's judgments and decisions (Dennett, 1991; Gazzaniga, 1989; Nisbett & Wilson, 1977). From the methodological point of view, this suggests that explanations provide no new data for the researcher, because the participants do not have privileged and private access to their JDM processes. Instead, they are assumed to rely on typical explanations that people use in similar cases. Study I specifically studied this claim. We found that participants' descriptions of their quality experience yielded a clear dimensional structure, which is unambiguously associated both with quality ratings and the ISP's that were evaluated in the study. The dimensions provided a picture about the relations of the relevant attributes of experience in that specific context, for example, the tradeoffs between sharpness and graininess, or between darkness and graininess. More importantly, the dimensions informed how quality in these cases could be enhanced by pointing out the optimum levels with these trade-offs. It does not appear plausible that participants would have relied on folk theories when they produced such sophisticated explanations for their ratings. It can be claimed that participants do not have access to the processes that determine judgments; however, they usually have privileged access to the subjective experience on which the judgments are based.

Although the IBQ method is not designed to probe the specific processes of judgments and decisions, it also provided information about what the relevant attributes are at different quality levels. Color distortion, for example, appears to degrade quality so that participants do not even consider other image properties in their ratings. Here, the prevailing strategy appears to be a simple lexicographic strategy. However, when the quality gets better, the descriptions of quality experience become richer, which probably reflects that fact that participants in this quality level are required to make trade-offs between different attributes, such as sharpness and graininess. The attribute space which determines the quality rating is therefore different in different quality levels, emphasizing the context-dependency of the JDM processes. In comparison with other methods, the use of predefined scales would, in this case, have masked these strategy differences in different levels of quality.

Taken together, the IBQ method, in this case, appears highly useful, as it opens the information used in the process of quality judgment to examination, and therefore gives a unique insight into how quality could be improved, supporting findings reported elsewhere (Häkkinen et al., 2008; Leisti et al., 2009; Radun et al., 2008, 2007). Evidence for fabrication (Claim 2) was non-existent, as indicated by inconsistent use of attributes, although this was not specifically tested in this experiment. As a conclusion, participants' explanations for their ratings appear to be authentic descriptions of subjective experience, which acts as an intermediate processing stage between the objective parameters of the alternatives and the behavioral response of the participants. Without understanding how the objective properties of the images were interpreted within this intermediate stage it would be difficult to explain the associations between objective properties and ratings.

The findings of Study I did not rule out the possibility that explaining one's ratings could distract the participant from the primary task, the quality estimation (Claim 3). Therefore we made an additional experiment, Study II, to find out the effect of explaining on high image quality, where differences between images approach the perceptual threshold and judgments require trade-offs between alternatives. This is a field of study where the IBQ method appears to be the most useful, as Study I suggests. The findings of Study II were quite clear: explaining the choices did not distract the participants from the task, on the contrary: participants were able to notice the quality differences better when they were asked to provide reasons for their choices. Explaining did not therefore distract from the task but benefitted it. Participants used strategies that were more compensatory, i.e. they attended more information in their judgments, thus making more reliable choices. The general consequence to the primary task, quality evaluation, was clearer differences between different samples, so no evidence existed to support the dilution effect (Nisbett et al., 1981), according to which preference differences are smaller between alternatives, when the choices are explained. This contrasts with Wilson's and Schooler's (1991) results, which have been regarded as evidence for not using explaining in JDM tasks. In conclusion, the effect of verbalization on JDM tasks should be evaluated case-wise.

Study III aimed to combine the findings from Study I and II, by quantitatively examining the correspondence between JDM behavior and the contents of the explanations. The purpose was to increase understanding about the different effects that are caused by introspection on judgments and decisions in different tasks. It further examined the reasons for the better performance in the explained condition (Claim 3) in Study II and also access to the JDM processes (Claim 1) and fabrication (Claim 2). The hypothesis was that predictable explanations should be related to better preference stability. This association suggests that the explanations reflect the underlying thought process that should also determine the choices. The participants who are unable to reflect their quality experience should perform worse in the tasks, thus having lower preference stability, whereas the situation should be the opposite for those who can reflect their experiences successfully. This should be dissociated from the *post hoc* explanations that would instead be associated with carefulness and other socially appropriate behavior and not with the underlying process of judgment.

The results of Study III show that a better understanding of one's JDM processes and the effect of explaining are associated so that lower understanding appears to be related to the maladaptive effects of explaining. We found that explaining made the participants make less intransitive choices, that is, they were more stable in their preferences. This effect, however, depended on how *predictable* the explanations were. Both explanations and choices thus appear to reflect the same underlying process. The result therefore gives no indication of fabrication.

To understand this phenomenon more deeply, we took an idiographic approach and analyzed what caused the changes in performance when participants proceeded from the first silent block to the second block, which required them to explain the choices. We found that those who were able to create predictable explanations were also those who managed to decrease the number of intransitive choices. This group, representing the majority of the participants, determined the overall result of the experiment, which suggested that explaining benefits judgments and decision in this particular task. However, those who could not create predictable explanations performed worse when explanations were required. The result may explain why conscious thought appears to have a distracting effect on certain tasks: in these tasks the majority of the participants are probably unable to find a coherent logic for their choices that otherwise are based on automatic responses.

Predictability was defined as the portion of attributes that could be predicted from the objective differences between alternatives. Predictability therefore relates to the concept of completeness (Wilson, 1994), which is opposite to the amount of information that participants omit from the subjective explanations of their choices. The random explanations were associated with random choices in Study III; the omission of information in the explanations hence appears to be related to the omission of information in JDM processes, leading to noisy processing and less consistent choices.

The other measure, *the consistency of the explanations* was not related to more stable preferences, but to better reliability (see Study II). Consistency is the portion of attributes that are used with the corresponding objective differences. A certain participant can be both consistent but not predictable when attributes of choice are created *post hoc*. Predictable attributes, on the other hand, suggest that the participant has a certain scheme that is followed in every decision. The result suggests that the generation of reasons that are grounded on objective differences is not enough; reasons should be used coherently. These two measures may reflect different processes: predictability may be related to the participants' aim to choose images logically on the basis of previous choices, whereas the consistency of explanations may reflect the participants' aim to find good justifications for their choices. The differences between explaining and justification are discussed in Section 5.3. The results suggest that there may be two mechanisms that mediate the effect of explaining on the JDM processes.

Study IV was carried out because in Study II the comparisons between conditions were made *within* subjects, and the block that required explanation was located in the second block, and the silent blocks before and after that block. There is always a possibility that the performance in the second block is better due to learning, and the performance in the third block worse due to fatigue. Therefore the experimental design in Study IV was changed: the first group of the participants first made the condition requiring explanations, and then the silent condition. In the second group of participants, the silent condition was made first, then the explanations condition. In the former group, no difference between blocks was found. However, in the latter group we found a large difference in performance between conditions.

Because the difference was measured within participants, there are two possibilities: the first possibility is that in the first group, participants learn a better strategy in the explanation condition, which is applied in the second block – therefore, there is no difference between blocks. In the second group, participants do not learn a better strategy until the second block requiring explanations. The second possibility is that explaining and learning have an independent, additive effect on the preference stability. Therefore two additional experiments were conducted to examine the role of learning in the task: first with explanations and second when completely silent. The results of these two studies suggest that explaining enhances learning and within-participant consistency. In particular, explaining appears to increase the weights of the less important attributes; for the most important attribute, there seems to be no difference whether the choices are explained or not. The result supports the idea that explaining can deepen the experience, thus leading to wider decision space.

The findings of all studies support the assumption that the effect of explaining on JDM is dependent on the task, the instructions given to the participant, and the participants' verbal ability to explain their decisions. More importantly, the results emphasize understanding the mental states and processes that are located between the presentation of the alternatives and the choice. Subjective experience therefore does not appear to play an epiphenomenal role in JDM processes. Additionally, the interaction between subjective experience (often referred to as intuition) and conscious thinking appears to be fruitful, and especially how multidimensional experiences are processed in JDM.

5.2 THE ROLE OF CONSCIOUS THOUGHT IN JDM BASED ON SUBJECTIVE EXPERIENCE

5.2.1 AUTOMATIC VS. VOLUNTARY PROCESSES

In the introduction, I presented claims that are often posed towards any method that is based on the elicitation of participants' subjective explanations for their choices. In the four studies presented in this dissertation, we showed that the claims are dependent on the context and do not to apply in the high image quality or similar evaluations. These results are not necessarily in contradiction to these earlier, opposite results though. Instead, they provide a more precise picture of human ability to introspect reasons for actions and the role of conscious thought in judgments and decisions.

These issues are closely intertwined with the dichotomy between automatic and controlled voluntary processes. Automatic processes are rapid and often employ parallel information processing (Schneider & Chein, 2003) and therefore they are noncompliant with the slow and serial nature of speech, making the verbalization of these processes impossible or at least difficult. Furthermore, increasing evidence suggests that judgments and decisions are often based on these automatic processes, which are present both in the creation of subjective experience and in the processes that integrate information to form preferences from the experience. This evidence is in line with the evolutionary idea that all animals are required to make choices with multiple alternatives and it seems plausible that the brain consists of mechanisms that serve the information integration needs of decisions efficiently so that coherent behavior would be possible.

A definite human feature, deliberative conscious thought (Baumeister & Masicampo, 2010), is expensive in terms of the allocation of limited attentional resources; reliance on conscious thinking for judgments and decisions therefore requires some kind of justification. Certain authors have concluded that this kind of justification cannot be found and have therefore denied the role of conscious thoughts on behavior altogether (e.g. Wegner, 2005). There are several reasons to think that this is not really the case: for example, it appears that all experiments that have stressed the role of non-conscious processes nevertheless use instructions given by the experimenter and the participants are expected to voluntarily follow these instructions (Baumeister et al., 2011; Dijksterhuis & Aarts, 2010).

Rather, it is more plausible that non-conscious and conscious processes interact in the control of behavior, and their roles differ between tasks (Baumeister et al., 2017; Williams & Poehlman, 2017). Automatic processes may produce a number of results that become conscious in subjective experience. These conscious experiences and the non-conscious information integration processes work in continuous interaction. Let us think of wine tasting, for instance. When we take a first mouthful of wine, we instantly make some kind of judgment of quality, which probably has a basis in evolution: we have to decide whether the drink is drinkable, spoiled or even poisonous. After this, we may perceive a number of other attributes by shifting our focus of attention. Our initial judgment of quality is not a result of consciously processing the attributes of taste, it is automatic. However, by focusing our attention on different aspects of the taste of wine, we can adjust our judgments and enrich our experience of quality. Recent evidence suggests that different attentional focus actually changes the subjective experience of taste, not how the aspects of subjective experience are integrated into judgments (Lee et al., 2006; Yamada et al., 2014). On the basis of our earlier experience or other contextual factors, we can therefore focus on different aspects of the wine, producing different quality estimations. Learning has a significant effect on the ability to make this kind of differential evaluation (Dijkstra et al., 2013; Hoeffler et al., 2013). As novices are not aware of the role of attention in the formation of judgments, they may be more vulnerable to context effects than experts, who are usually aware of their processes (McGlone et al., 2005; Yamada, 2009). In this way, even the automatic processes that are involved in the creation of our experiences can be under voluntary control.

Instead of direct access, consciousness appears to have this kind of indirect introspective access to the JDM processes, which is based on learning in similar tasks (Jack & Shallice, 2001). While making different kinds of decisions, an individual can gradually learn which aspects of subjective experience co-occur with preferences. This is supported by the findings indicating that understanding one’s own preferences develops when experience is gathered (Dijkstra et al., 2013; McGlone et al., 2005; Yamada, 2009). This understanding represents metacognitive knowledge (Frith, 2012; Nelson, 1996), that is, higher-order thoughts (Cleeremans, 2011; Timmermans, Schilbach, Pasquali, & Cleeremans, 2012) about the JDM processes, not knowledge that is obtained by directly accessing these processes. In a similar fashion, people learn to evaluate the degree of certainty when they are asked whether they perceived a near-threshold stimulus or whether they know the right answer to a certain question (Timmermans et al., 2012). Cleeremans (2011) suggests that consciousness in general develops gradually when the brain learns to predict the consequences of its own actions. In other words, consciousness results from meta-level representations that are directed towards the brain itself. After one has developed conscious awareness, or a metacognitive ability to monitor these actions, they come under voluntary control (Cleeremans & Jiménez, 2002; Nelson, 1996).

Other authors have also pointed out the association between consciousness and the ability of the brain to predict how the environment responds to different kinds of actions (O'Regan & Noë, 2001). In this framework, the different "blindness" phenomena, such as inattentional blindness or change blindness, are explained by their irregular, unpredictable nature (Cohen et al., 2016): information in these cases fails to be noticed as it is not represented in the predictions the brain has made about the surrounding world. Choice blindness (Johansson et al., 2006) suggests that this applies to the metacognitive awareness for the reasons of the decisions, too: due to an extremely improbable and unpredictable event (e.g. the experimenter performing a magic trick), the research participants are unable to gain a metacognitive understanding that they are being cheated. Instead, they continue as they normally would do and explain their choices as nothing was wrong, relying on the predictions of how they would prefer things in similar occasions. As metacognition and the processes that are the targets of metacognition are dissociated (Dehaene et al., 2017), individuals are unable to notice that their metacognitions are incorrect.

In Study II, we suggested that introspection may work in concert with attentional mechanisms. Accumulating evidence suggests that inner speech (a verbal form of conscious thinking) facilitates attention, and that attention is accessible to introspection (Bastian et al., 2017; Emerson & Miyake, 2003). Although we may not control how information is integrated in automatic processes, we may control what information is fed into those processes by attracting our attention to different features. "We" refer, in this case, to our conscious mental processes, the experiment instructions, schemas, narratives, rules or similar things that we may voluntarily follow. Often these include at least rudimentary inner speech. Requiring explanations for decisions can evoke inner speech and thus facilitate attention to different aspects. Attended information becomes phenomenally conscious (that is, experienced) and is therefore available in the perceptual decision space for non-conscious information integration processes (Morsella et al., 2016). This may further be amplified by the feeling of accountability, which often follows from the requirement to justify one's actions.

This link between voluntary attention and conscious thought reflects one of the central claims of this dissertation. Although we are not often able to consciously reflect the processes that integrate information and determine our experiences, we are usually able to describe a rich subjective experience. By shifting our voluntary attention, we can further *learn* the association between information that is fed into automatic processes and the subjective experience which results from those processes.

With high image quality estimation, the differences are small and often not salient. Because of this, finding differences may require effortful search, that is, the deliberate use of visual attention, which is enhanced by explaining. These findings may apply to JDM phenomena in general. The widespread idea of preference construction probably refers to this information search process and not to the actual information integration processes (Glöckner & Betsch, 2008b). It appears that effective automatic information integration requires the information to be first consciously attended (Nordgren et al., 2011) before a gist representation of the decision problem can emerge by means of the automatic processes (Abadie, Waroquier, et al., 2013). This gist summarizes the fit of the alternatives, which can be used as a basis for decision. These recent results are in line with the idea that the function of subjective experience is to present a decision space which contains information that forms the basis of voluntary actions (Morsella et al., 2016).

5.2.2 CREATION OF NARRATIVES, LEARNING AND RATIONALITY IN JDM

In addition to metacognition, the ability to explain one's JDM processes probably has a cultural, social and developmental basis (Baumeister & Masicampo, 2010; Frith, 2012). It is learned by interacting with others. Language helps to name different experiences, adopt the causal narratives about the associations between different experiences and their consequences, and share the experiences with other people, thus developing a pool of shared understanding of what is good and bad and how judgments are formed in different contexts. This is how we know that images described as "sharp" are good and images described as "grainy" are not, without even looking at the actual images.

In the introduction, we presented the reasoning-as-theorizing account (Dennett, 1991; Gazzaniga, 1989; Nisbett & Wilson, 1977; Wilson, 2002), which states that the explanations people use for justifying their choices are not true descriptions of their actual decision-making processes but, rather, are causal theories about those processes to which they have no access. This suggests that thoughts relating to JDM are epiphenomenal in character: they have no role in determining human behavior. Support for this account has been found in experiments where participants make rather mindless choices and are then required to explain their actions (Johansson et al., 2006; Nisbett & Wilson, 1977). In these cases, participants indeed fabricate their explanations, as they have usually lost their memory traces about the underlying experiences.

When subjective explanations are conceptualized as metacognition, the question whether people can access their JDM processes becomes irrelevant. The theorizing relating to the reasons for decisions can, in fact, be a part of the learning process, where people can create metacognitive understanding about their preferences (Frith, 2012): people have a tendency to create narratives that describe causal and other relations between different phenomena to make their behavior understandable to themselves and to other people (Dennett, 1991; Gazzaniga, 1989; Mercier & Sperber, 2011). These metacognitive narratives can be modified and corrected in social interaction to better match with the actual cognitive processes (Frith, 2012). When confronted with similar decisions in the future, people may refer to these narratives to find a solution and so the narratives that people create later start to control their behaviors (Dennett, 1991; Gallagher, 2000). They can act as hypotheses for successful or unsuccessful decisions, which guide behavior when an individual is confronted by further choices (Baumeister & Masicampo, 2010; Frith, 2012; Hagafors & Brehmer, 1983). This is manifested in more consistent behaviors across several choices. This mechanism probably enabled learning in Study IV.

By using this understanding, consciousness can detach the individual from immediate experiences and default responses, therefore bringing consistency to behavior in the long run. Rationality emerges from this kind of interaction with the environment on the basis of theories and expectations (Felin et al., 2017): humans do not have prior knowledge about how rational behavioral occurs; it is learned from the social environment and from one's own experiences.

Study IV thus offers a new, often neglected role for conscious thinking in judgment and decision making: it can support learning. Generally, this aspect of conscious thought which enhances coherency in the long run appears worth further research. Ahlum-Heath & Di Vesta (1986) have suggested that verbalization creates overt commitment to the rules that individuals apply in a task. On the other hand, mere attention to the trade-offs can enhance the consolidation of the weights of the attributes (Dijksterhuis & Aarts, 2010; Hoeffler & Ariely, 1999). Berry and Broadbent (1984) showed in their dynamic decision-making task that when research participants have been given explanations for the right decisions in previous trials, verbalization benefitted their performance more than just the silent condition. The reason was this effect was assumed to emerge from a synergy between explanations *given* to the participants and verbalizations, as the participants tried to apply a similar logic in their verbalizations as was present the experimenters' explanations. This may reflect the role of conscious thought in the application of culturally normative reasoning in JDM. This social aspect of decision making is often ignored (Felin et al., 2017) and the biases and rationality literature has been individualistic. Hence, the rationality of the JDM behavior should also be studied in relation to human interaction in social, institutional and organizational settings.

5.3 INTERFERENCE OF VERBALIZATION WITH JDM PROCESSES

In addition to the concerns relating to access and fabrication, the verbalization of reasons for decisions has been assumed to interfere with primary JDM processes (Levine et al., 1996; McMackin & Slovic, 2000; Wilson et al., 1993; Wilson & Schooler, 1991). This interference does not have only negative consequences: it has been suggested that verbalization interferes with intuitive tasks but benefits analytical tasks, and it is assumed that this occurs because verbal processes are analytic in nature. Therefore explaining is assumed to force the individual to shift the processing to a more analytical and conscious mode (Baumeister et al., 2011; Dijksterhuis, 2004; Hamilton et al., 2007; Hammond et al., 1987). As a consequence, it has been quite a popular experimental manipulation (Baumeister et al., 2011; Hamilton et al., 2007): by asking one group of participants to explain their decisions when the other group makes the decisions silently, makes it possible to examine the differences between analytical and intuitive thinking. On the other hand, explaining has also been conceptualized as a form of accountability, which makes the individuals voluntary change the ways they process information so they would not appear foolish in front of other people (Lerner & Tetlock, 1999).

So, is the change following the requirement to explain one's decisions due to a processing shift or to accountability? Table 2 combines these aspects. It assumes that a match between the tasks and the processing style is moderated by accountability. Analytical tasks that are executed using conscious thought are based on the application of culturally shared logic, whereas intuitive tasks are based on subjective experience. A somewhat different typology was presented by Ericsson (2003b), who categorized different types of verbalization in three classes, consisting of inner speech, explaining and introspection. Inner speech should have no effect on processes. Explaining, on the other hand, has beneficial consequences. Introspection involves additional observation in addition to think-aloud observation.

Thinking aloud is by far the most investigated type of verbalization (Fox et al., 2011). It consists of verbalization of inner speech, the verbal content of conscious thought, without accountability or the social pressure to become understandable. In other words, participants in this case are only asked to think aloud without reflecting on or interpreting their thoughts. Much evidence suggests that this kind of verbalization does not interfere with primary tasks. However, it requires that the primary task should have a verbal form and it should be solved by manipulating this information in the working memory (Ericsson & Simon, 1980). In other words, thinking aloud only explicates the decisions that are based on conscious reasoning.

Table 2. *Typology of verbalization as a function of accountability and the mental content determining the decision.*

		Presence of accountability	
		Accountability	No accountability
Mental content determining the decision	Subjective experience	*Justification*	*Description of experience*
	Conscious thought	*Explaining*	*Thinking aloud*

Description of an experience is the counterpart to thinking aloud in the context of phenomenal consciousness, in a sense that is lacks the accountability and the pressure of being understandable. In other words, it lacks the explicit logic of conscious thought. It consists of verbalization of subjective experience and it should exclude any interpretative content (Petitmengin & Bitbol, 2009). So far, this type of verbalization is understudied. It has been suggested that performing the description of experience should be beneficial or at least neutral when conducted properly (Petitmengin et al., 2013). This means that participants are instructed to focus on experiences and not on their thoughts, which may require practice. As the two types of verbalization do not cause the processing shift from a more intuitive and experiential mode towards a more analytical and conscious mode, it appears that the processing shift requires accountability.

When participants explain their actions, they try to make their actions understandable. This aspect differentiates explaining from previous types of verbalizations which lack this kind of accountability. Explanations are expected to be dependent on a socially shared logic of how decisions should generally be made. If an individual has a disposition towards a more intuitive solution, this is commonly assumed to shift processing towards a more explicit, or conscious and verbal mode, which can explicate this can kind of shared verbal logic. Whether this shift benefits or distracts the individuals' performance is dependent on their metacognitive understanding about the JDM processes in the task in question (Dijkstra et al., 2013). If the task generally benefits from a logical approach, explaining has been shown to enhance performance (Fox et al., 2011). This, of course, requires that the individual in question has some kind of idea of the rules that should be followed. Personal preferences can often ignore socially shared logic and can therefore be difficult to explain, which may lead individuals to temporarily change their preferences. The results presented in this dissertation suggest that explaining can also benefit certain JDM tasks that are based on subjective experiences. These tasks might, for example, require more effortful information search. This may deepen the experience and lead to a wider decision space.

When decisions that are based on subjective experience are explained to others, the process is here called justification. If one would normally approach a certain JDM problem intuitively, basing it on a certain subjective feeling, the requirement to provide reasons for that decision can lead to two alternative consequences. The first is that the individual changes the mode of processing towards a more conscious mode and *explains* how a certain conclusion has been reached. The second alternative is that the individual still makes the decision intuitively and *justifies* it. Justification therefore differs from explaining in the sense that it is made post hoc; it is created afterwards, while explaining occurs on-line, even if it is reported after the decision. Hence justification lacks the interaction between thoughts and subjective experience. In its strictest sense, justification is therefore a form of fabrication. From the viewpoint that is adopted in this dissertation, justifications represent the personal metacognitive understanding about the JDM process. Whether these metacognitions are correct depends on the learning history and the typicality of the task. From the description of the experience, which basically describes the decision space, justification differs by being a causal narrative which interprets how the decision was made on the basis of that decision space.

5.4 SHIFTING VIEWS ON INTROSPECTION?

Although cognitive psychology does not rely on behavioristic stimulus-response (S-R) connections in its theoretical conceptualizations, this approach is still prevalent in its methodology (Costall, 2006). In many respects, this also applies to research on JDM: participants in experiments are given some information about alternatives and their corresponding attributes (stimulus) and they are asked to make a choice between alternatives (response). The process-tracing tradition, of course, exists, but it does not differ from more behavioristic approaches in its concern with objectivity (e.g. Ericsson & Simon, 1980; Fox C. et al., 2011) and therefore subjective descriptions of the reasons for decisions have been treated with suspicion. Moreover, subjective experience has often been viewed as a source of biases – as the heuristics and biases research program suggests (Kahneman, 2003) – rather than a relevant intermediate stage of processing. It is somewhat ironic that subjective experience, in fact, has a major role in psychological research as responses, but not as mediators (Costall, 2006). Psychophysics and personality and social psychology, for instance, often rely on self-reports. Despite this interest in subjective experience as a response to stimuli, the attitudes towards the mediating role of subjective experience have been skeptical (D. A. Lieberman, 1979).

The behaviorist S-R approach is actually a false simplification of the experimental procedure in psychological experiments, because the response always follows the script that is given to the participants by the experimenter: the instructions tell participants how they should interpret the stimuli and how they should act on them (Jack & Roepstorff, 2002). Despite the common instructions given to the participants prior to the experiment, the interpretations about the experimental task can differ. If one is asked to estimate quality, the personal definition of quality or personal taste can differ, causing “errors” in the data. In all experiments presented here, participants were asked to make multidimensional judgments. The task requires participants to figure out the differences between alternatives; determine the valence, that is, the goodness or badness of these differences and determine the weight or the importance of each difference. In other words, there are countless ways the participants could interpret the task, stated simply as “which one of the images do you prefer?” Without knowing the interpretation, we do not know the script that participants are actually following and causing differences in the participants’ behavior. Study III is an example of this approach: we could explain both better and worse task performance on the basis of the verbal data provided by the participants. This made it possible to understand the contradictory effects of explaining in different studies. Without this participant-centric approach, we may have only made conclusions on the basis of mean performance.

When the behavioral response is a counterpart of the stimulus, Jack and Roepstorff (2002) regard verbal reports as a counterpart of the script. Verbal reports can make the differences between different interpretations explicit, making the behavior of the participants understandable. In some cases, the research participants’ peculiar responses may become understandable when their interpretation of the task is explicated (Leisti et al., 2008). Our present studies, on the other hand, suggest that participants do not make choices analytically on the basis of the objective attributes of the alternatives, nor do they make them non-consciously; rather they are making decisions quasi-analytically on the basis of a few subjective and experiential dimensions that appear relevant to the task and become represented in awareness. Hence, knowing these dimensions is crucial for understanding people’s preferences. The theme of this dissertation emphasizes the role of the interaction between conscious thought and subjective experience, therefore opposing the recent trend which stresses non-conscious processes (Baumeister et al 2017, Williams & Poehlman, 2017; Plassman & Mormann, 2017).

Additionally, the scientific publication process can sometimes bias the way certain phenomena are viewed. Self-reflection and deliberation are usually considered beneficial behaviors; that they should be a disadvantage appears counter-intuitive and naturally interests both researchers and lay people. This may result in a larger number of citations and thus a larger impact. In the eighties, scientific articles concerning bad decision making were found to attract many more citations than articles about good decision making, and this was found to have a significant effect on psychologists' attitudes towards people's ability to make good decisions (Christensen-Szalanski & Beach, 1984). A vast amount of research where humans are shown to perform well have had little attention paid to them (Felin et al., 2017).

Psychological experimentation often exploits a strategy of designing experiments by using somewhat peculiar and unusual tasks, so that participants can be induced into doing something counter-intuitive or even irrational (Simonson, 2008). This is often important as it can cast light on the underlying processes when people do not behave according to the predictions of normative economic theories. Unfortunately, these results are often generalized without taking into account the original, unusual condition in which the original task was carried out. For example, participants in Experiment 2 of Wilson's and Schooler's (1991) study were asked to "introspect" their decisions by using rating scales. It appears that this form of involuntary mode of reflection interfered with their own way of evaluating the alternatives by focusing their attention on the aspects given by the experimenter (Tordesillas & Chaiken, 1999). Wilson & Schooler (1991) actually suggested that their findings should not be generalized everywhere; introspection can sometimes be detrimental but their results do not imply that this is always the case. In spite of this, their results have been seen as evidence that any method that relies on subjective explanations for actions is invalid.

Nevertheless, discussion about the ability to introspect subjective experiences is gradually shifting from a categorical yes-no dispute to the examination of conditions that facilitate or hinder successful introspection. Wilson (Hofmann & Wilson, 2010) and Schooler (Schooler & Schreiber, 2004), who had initially warned about the interfering effect of introspection on JDM, preferences and attitudes, now emphasize that reliable introspection is possible when an individual has the ability to concentrate on a subjective experience. Other authors have presented similar ideas (Locke, 2009). This ability appears to be related to, for example, the ability to concentrate on present experience, which also has other beneficial effects (Tang et al., 2015). The changing views may reflect the fact that consciousness has gradually become a respectable area of scientific study after decades of methodological behaviorism.

The results of this research suggest that the claims that have emphasized the fallibility of introspective self-reports and the maladaptive effect of self-reflection may have attracted too much weight in the literature. However, as recent research appears to undermine the role of conscious thought, it would seem that there is a need for understanding the role of subjective experience in human behavior. Gore and Sadler-Smith (2011) call for a systematic research program on the phenomenological side of intuition, focusing on how intuition presents itself to us. The IBQ approach could give some insights on that issue, too.

5.5 CONCLUSIONS

This dissertation started by describing the social importance of the ability to explain one's judgments and decisions to other people. This perspective has been quite prevalent in basic research, emphasizing the role of conscious thought both in the JDM processes and the social nature of the explanations. Another important theme emphasized the unique, subjective point of view, which is manifested in subjective experience, which forms a basis for personal judgments and decisions. The latter theme has been prevalent in the development of the IBQ method and other similar approaches that are based on examining aspects of subjective experience. The purpose of this dissertation was to integrate these views, as academic psychology tends to be highly skeptical towards this kind of subjective data, whereas its use within the applied sciences appears to lack this prejudice.

Contrary to common claims from psychological basic research, explaining was found to benefit the visual judgment and decision making tasks employed in this dissertation. Nor was the claim that explanations are fabrications supported by our research: those who were able to create more predictable explanations were also more coherent in their choices. We also found that explaining allowed participants to weight the information more consistently. From the practical point of view, when methods that rely on participants' verbal description of their experiences are used, it should somehow be ascertained that participants focus properly on their experiences instead of applying a stock theory of how their judgment should have been formed.

Both reliance on conscious thinking and reliance on subjective experience have been seen as sources of irrationality. The results of the experiments presented in this dissertation emphasize rationality in context. Benefits of conscious thought materialize in interaction with social and developmental contexts (Baumeister & Masicampo, 2010; Felin et al., 2017; Mercier & Sperber, 2011). Subjective experience, on the other hand, leads to rationality when it is combined with expertise.

Finally, the society around the academic environment usually requires knowledge about subjective experience. The qualitative approaches in food sciences, for example, suggest a strong interest in subjective experience. In addition, social sciences increasingly emphasize experiential data. That people's experiences are respected is a generally positive social change and therefore there is a growing applied need for understanding subjective experiences and how they relate to thinking and objective facts. Condemning subjective experience as an unreliable source of information makes little sense when there is a growing requirement for understanding personal experiences.

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