Interest-driven Attention in Viewing vocational-related Imagery

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Patricia Malitzke
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1. Berichterstatter/-in:	Prof. Dr. Stephan Schwan
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Summary

This doctoral dissertation investigates the relationship between eye movement behaviour and vocational interests. The primary objective is to examine how individual personality characteristics–specifically vocational interests–influence visual perception when individuals are presented with complex visual stimuli. This novel approach was selected to address common limitations associated with traditional career assessment methods, such as language dependency, social desirability bias, and extreme response tendencies. By utilising eye tracking technology, the research aims to provide a more objective and behaviour-based alternative. Three empirical studies were conducted involving a total of 317 adolescents aged 16 to 19, recruited from German secondary schools and career fairs. Participants viewed two complex visual stimuli, each depicting six representative occupations based on John L. Holland's RIASEC model. During the task, an eye tracker recorded multiple metrics, including fixation count, dwell time, and saccade count. In addition to the eye tracking procedure, participants completed a standardised vocational interest assessment (AIST-3) and provided image-based ratings. Linear regression analyses were employed to explore the associations between eye tracking variables, image rating scores, AIST-3 scores, and AIST-3 item response times. The findings indicate that the strength of vocational interest is significantly associated with dwell time, fixation count, and image rating scores. In contrast, the assessment of career decision certainty proved more complex; only a weak correlation was observed between saccade count and self-reported certainty. Overall, the results support the existence of fundamental links between eye movements and vocational interest. These findings contribute to the development of a novel and promising methodology for assessing vocational interests through eye tracking technology.

Zusammenfassung (deutsch)

Diese Doktorarbeit untersucht den Zusammenhang zwischen Augenbewegungen und Berufsinteressen. Es wurde analysiert, wie individuelle Persönlichkeitsmerkmale die Wahrnehmung von komplexen visuellen Stimuli beeinflussen. Dieser Ansatz wurde gewählt, um Einschränkungen von traditionellen Berufsinteressentests zu umgehen, wie etwa Verständnisprobleme durch text-basierte Items, Antworten aufgrund von sozialer Erwünschtheit oder extrem ausgeprägten Antworttendenzen. Eye Tracking dient als eine objektivere und verhaltensorientierte Datenerhebungsmethode. Im Rahmen der Arbeit wurden drei empirische Studien durchgeführt. Die Stichproben bestanden aus insgesamt 317 Jugendlichen im Alter von 16 bis 19 Jahren, die an deutschen weiterführenden Schulen sowie auf Berufsmessen rekrutiert wurden. Die Teilnehmenden betrachteten zwei komplexe Bilder mit jeweils sechs Berufen. Die Stimuli wurden anhand des RIASEC-Modells von John L. Holland gestaltet. Während der Betrachtung erfasste ein Eye Tracker mehrere Parameter, darunter die Fixationsanzahl, Betrachtungsdauer und Sakkadenzahl. Ergänzend zum Eye Tracking beantworteten die Teilnehmenden einen standardisierten Berufsinteressentest (AIST-3) und bewerteten die Berufsbilder. Mit linearen Regressionsanalysen wurden Zusammenhänge zwischen den Eye-Tracking-Variablen, Bildbewertungen, AIST-3-Scores sowie den Antwortzeiten der AIST-3 Items untersucht. Die Ergebnisse zeigen, dass die Ausprägung beruflicher Interessen signifikant mit der Betrachtungsdauer, der Anzahl der Fixationen sowie den Bildbewertungen korreliert. Die Selbsteinschätzung der beruflichen Entscheidungssicherheit erwies sich hingegen als komplexer: Es wurde nur ein schwacher Zusammenhang zwischen der Sakkadenzahl und der Entscheidungssicherheit festgestellt. Zusammenfassend deuten die Ergebnisse dieser Arbeit auf grundlegende Zusammenhänge zwischen Augenbewegungen und Berufsinteressen hin. Die Erkenntnisse leisten einen wertvollen Beitrag zur Entwicklung einer innovativen Erfassung beruflicher Interessen mittels Eye Tracking.

1 General Introduction

The willingness to explore interdisciplinary research fields and to establish theoretical foundations that support practical applications characterises this dissertation. The main goal is to investigate a new approach of analysing vocational interest via eye movements. This concept is grounded in two key considerations, the first being the career choice process as a complex decision-making challenge faced by today's adolescents. Growing up, we were often asked: 'What do you want to be when you grow up?' As individuals get older, the significance of the answer increases, but the choice of a career does not become easier. In Germany, school leavers can select a career path from a wide range of vocational training programmes, including 328 state-recognised apprenticeships and 9,893 bachelor study programmes (Bundesministerium für Bildung und Forschung, 2024; Hochschulrektorenkonferenz [HRK], 2023). Today, young people have a wide variety of career paths to choose. Therefore, it is not surprising that adolescents find it even more difficult to make a decision (Anger et al., 2024). To optimally support students in their career decision-making process, it is essential to consider alternative approaches alongside traditional career counselling methods. These alternatives should align with the digital environment in which adolescents live today. One promising technology in this context is eye tracking, which is increasingly being utilised across various technological domains.

The second consideration is based on the growing body of evidence demonstrating that eye tracking data can reveal a wide range of individual characteristics. Eye movements serve as indicators of underlying cognitive processes and have been shown to provide insights into both physical and mental health status. Moreover, research suggests that eye tracking metrics are associated with personality traits, cognitive abilities, and specific skills (Al-Samarraie et al., 2018; Gegenfurtner et al., 2011; Kröger et al., 2020; Orquin & Mueller Loose, 2013). Despite these research areas, the relationship between eye movement behaviour and interests remains largely unexplored. Furthermore, eye tracking provides great potential for practical application–particularly in the development of a visual vocational interest assessment.

This dissertation is structured into three main chapters. Part One (Chapter 1 – General Introduction) offers a comprehensive overview of the two primary research domains: vocational interests and eye movement behaviour, with a particular focus on interest-driven visual perception. Part Two (Chapter 2 – Dissertation Overview) introduces the three manuscripts (partially published) that constitute the core empirical investigations of this dissertation. Part Three encompasses Chapter 3 – General Discussion and Chapter 4 – Conclusion, wherein the key findings from the three studies are synthesised, their theoretical contributions to the respective research fields are critically examined, and their practical implications for career counselling are discussed. Additionally, it addresses the strengths and limitations of the studies and highlights avenues for future research, particularly regarding the development and implementation of a standardised visual vocational interest assessment tool.

1.1 Interest viewed from the perspective of vocational behaviour

In the following section, the construct of interest is examined in greater depth. While the term ‘interest’ is frequently used in both everyday discourse and academic contexts, its meanings can vary considerably. To establish conceptual clarity, the section begins by delineating the specific perspective through which interest is approached in this work. Subsequently, the focus shifts to the domain of vocational interests. The evolution of theoretical frameworks concerning vocational interests is outlined through the presentation of key frameworks, culminating in the introduction of the widely recognised RIASEC model, which currently represents the predominant paradigm in the field. Finally, assessment instruments used to measure vocational interests are reviewed, providing a comprehensive overview of current methodologies and practices in the field.

The concept of interest originates from the Latin roots ‘inter’ (meaning ‘between’) and ‘esse’ (meaning ‘to be’), implying a relational engagement between an individual and an object. In psychological terms, interest arises when an individual directs sustained attention toward a particular target–such as an activity, person, or goal. This construct is deeply intertwined with personal values and intrinsic needs, serving as a critical motivational force that influences behaviour, learning, and goal-directed action (American Psychological Association, n.d.; Wirtz, n.d.).

Interest is the subject of research across various fields such as emotional and motivational psychology, work and organisational psychology, educational psychology or vocational psychology. Interests are distinguished between interest state and interest trait. The interest state is a short-term situational interest. It is triggered by external stimuli and leads to an affective reaction. Situational interest is accompanied by focused attention on the object of interest and forms the basis for the development of individual interest (Hidi, 1990; Hidi & Renninger, 2006). An example: A person flips through a magazine and stops at a colourful advertisement. The design captures their attention, prompting them to take a closer look and read the advertisement in detail.

In contrast, interest trait is a longer-lasting individual interest. A feature of individual interest is an enduring reengagement over time with an object or situation (Hidi & Renninger, 2006). This requires repeated attention, emotions, curiosity, and motivation; otherwise, the interest will fade. Thus, a constant, positive high activation is linked to interest (Watson et al., 1988). For example, when someone has an interest in playing the piano, they practice pieces regularly, engage with playing techniques, and are open to anything related to piano playing.

In the *four-phase model* of Hidi and Renninger (2006) and the *Trait-State Interest Dynamics* of Su et al. (2019) situational interest always precedes individual interest. Consistent with the progression of interest development, both cognitive load and positive affect tend to increase. During the initial phase of triggered situational interest, there is relatively limited cognitive evaluation–such as the recall of prior knowledge–and moderate positive affect. However, as interest becomes more well-developed and individualised, both cognitive engagement and positive emotional response can rise to a maximum (Hidi et al., 2004).

The present work focusses on the longer-lasting individual interest as a personality trait and disposition. The studies in this dissertation used situational interest, in the form of occupational images, to trigger an individual interest in the form of vocational interest.

Research on interest as a psychological trait has developed in three areas (Su, 2020). In vocational psychology, studies focus on the impact of interest on career decision-making. Within organisational psychology, the relationship between individual interests and job performance is investigated. In educational psychology, interest is examined as a key factor influencing learning processes and motivation. Interest trait is a key variable in occupational aptitude diagnostics, and therefore much research is still being done in the field of vocational behaviour (Du et al., 2023; Liu et al., 2021; Schermer, 2017; Spurk, 2021; Su, 2020; Volodina & Nagy, 2016; Walsh & Osipow, 1986).

Vocational interest is defined as relatively stable cognitive, emotional, or value-based tendencies towards certain actions and are considered as dispositional interindividual differences (Bergmann & Eder, 2019; Rounds & Su, 2014). Research in the field of vocational interest is conducted from a structure-orientated perspective, which focusses on constant individual interests (Krapp, 2018).

Career choice is influenced by several factors, including personality traits, self-concept, cultural background, attitudes, and values. Among these, vocational interests represent a key intrinsic component (Korkmaz, 2015). Research has shown that vocational interest is one of the most reliable predictors of career choices during adolescence, helping to shape preferences for certain types of work (Volodina & Nagy, 2016). It also plays a guiding role in shaping individuals' occupational plans, intentions, and aspirations (Lent et al., 1994).

Recent studies have yielded some important insights into:

- Vocational interest and occupational fit
  (Gati et al., 1998; Lipshits-Braziler et al., 2024; Tracey & Hopkins, 2001)
- Vocational interest and self-efficacy
  (Tracey, 2010)
- Stability and change of vocational interest
  (Ertl et al., 2023; cf. Etzel & Nagy, 2021; Pässler & Hell, 2020)

Career choices are based on a large congruence of vocational interests and the characteristics of occupational environments. This person-environment match is the subject of several vocational interest theories, such as Holland's RIASEC model, and career counselling tools (like the AIST-3). In the matching process, work-related activities are compared to the conditions of the professional environment (Holland, 1997).

The following sections dive deeper into the theories and assessments of vocational interest. They outline the development of vocational interest models and explain the relevance of the person-environment fit.

1.1.1 Overview of vocational interest theories

Several models try to explain the complex interplay between persons and occupational environments. The following sections present five well-established models of vocational interest, which serve as foundational frameworks for subsequent theoretical developments and are commonly applied in practical career counselling. The first framework, *Parsons' Trait and Factor Theory*, laid the groundwork for a standardised approach to career decision-making, introducing the concept of matching individual traits with occupational requirements. Building on this, *Super's Life-Space Theory* highlighted the developmental nature of career choice, emphasising that it is a lifelong process rather than one confined to adolescence. *Roe's theory of career choice* focused on the role of early parental influence in shaping career interests, proposing that familial relationships significantly impact vocational interests. *Gottfredson's Occupational Aptitude Patterns (OAP)* further expanded the understanding of career development by incorporating career interests alongside cognitive abilities and intelligence as key factors in achieving a satisfactory occupational fit. Finally, *Holland's RIASEC model*, which remains one of the most widely applied frameworks in career counselling worldwide, serves as the foundation for numerous career interest assessments.

Parsons' Trait and Factor Theory

Frank Parsons (1854–1908) was a social reformer and the founder of vocational guidance in the 20th century. He received formal education in both civil engineering and law, and held academic positions as a Professor of Law at Boston University and as a Professor of Political Science and History at Kansas State Agricultural College (Mann, 1950). His posthumously published manuscript 'Choosing a vocation' is an extensive compendium of recommendations for vocational choice processes (Parsons, 1909). Parsons' ideas were grounded in Charles Darwin's theory of evolution and adapted the person-environment matching to vocational psychology (Baker, 2009). He designed a scientifically grounded framework for career counselling which had not previously existed in this format. Frank Parsons was consistently guided by his vision of a cooperative and humane society, in which individuals possess the right to pursue their personal development freely (Jones, 1994).

To guide individuals to a wise career choice, Parsons defined three factors, in which career counselling is necessary: First, adolescents should have to gain a clear understanding of their skills, aspirations, personal suitability, financial resources, potential limitations, and interests. Therefore, a career counsellor guides them through comprehensive questionnaires and conducts one-on-one interviews to help the young people reflect on themselves. For the second factor, young adults should acquire a complete understanding of various career options, which Parsons referred to as 'opportunities'. To facilitate this, Parsons categorised the occupations and assigned them defining characteristics. These characteristics include not only the personality traits typical of workers in a given field, but also company-specific traits, such as locations, market leadership, or distribution channels. The categories are as follows (Parsons, 1909):

- Agri-, Horti- and Floriculture, etc.
- Stock-raising, dairying, and other animal industries
- Mining, quarrying, etc.
- Mechanical trades, manufacturing and construction, transportation, etc.
- Commerce: wholesale and retail, buying and selling
- Finance, banking, investment, etc.
- Agencies, office work, etc.

The third factor is an expedient analysis of the relationship between the personal reflection and the occupational facts. Since the *Trait and Factor Theory* is primarily centred on career counselling, the role of the counsellor is to align the young person's personality traits and preferences with suitable occupational opportunities. A match is seen as the key to establish the foundation for a fulfilling and successful professional life (Parsons, 1909).

Parsons' *Trait and Factor Theory* forms the foundation of many subsequent vocational interest models. While it does not focus specifically on vocational interests, it provides a framework for organising and understanding them. A key concept that remains central in modern vocational interest theory and assessment is the person–environment fit.

Super's Life Space Theory

Donald E. Super's *Life Space Theory* is a career development framework that addresses vocational interests. Super was an American developmental psychologist and career theorist. The idea for his framework was driven by the assumption that career choice is a lifelong process in which individuals take on different roles. Super was the first who viewed career development in this way. It combines various approaches from psychology, sociology, philosophy, and other sciences. The theory aims to combine various areas and covers not only career choices in young age but also career development throughout life. According to the theory, individuals take on nine roles in the course of their lives (Super, 1980):

1. Child,
2. Student,
3. Leisurite,
4. Citizen,
5. Worker,
6. Spouse,
7. Homemaker,
8. Parent,
9. and Pensioner.

Some of the roles are taken separately, such as child, and others are taken simultaneously, such as spouse and worker. The intersection of the different life roles is symbolised as a career rainbow (see Figure 1 in Super, 1980). This representation illustrates the multidimensional careers, the temporal involvement, and the emotional commitment of individuals to each life role. The roles have a major impact on personality. It has a stereotypical chronological order, but in real life the order can change and some people do not take all of the nine roles (e. g., someone dies young or before retirement) (Super, 1976).

In contrast to Parsons' *Trait and Factor Theory*, Super's theory implies cognitive approaches, such as looking for new occupational information which are collected, compared and stored for later reference in short and long-term memory. Vocational interests are subject to decision-making, in which the individual conducts an active role in the decision-making process. Thus, personal and situational determinants have a decisive influence on the career decision. Personal factors include, for example, awareness, attention, and interest. Situational factors include, for instance, geographic and economic factors. Super distinguishes between the terms *career* and *occupation*. Careers are general life positions that are taken over a specific time of life. Various careers can coexist at the same time. Occupations are occupational positions which are taken over a specific time of life and vary with growing knowledge or a change in job. Some people have two or more occupations at the same time, for example, engineer during the day and security guard at night (Super, 1980).

Super's theory addresses the challenges, individuals have in their different roles in life. His considerations are strongly based on time and illustrate how diverse personalities can be. Cognitive abilities, behavioural patterns, and emotional involvements are adapting to different environments and people. The theory describes how the mix of roles affects personality. Interest and abilities are thereby the motor that drives individuals to certain activities and affects our satisfaction with the relevant career trajectory (Super, 1980).

Roe’s theory of career choice and Gottfredson’s OAP

In this section, the concept of vocational interest in career choice is further explored by two more theories of Roe (1956) and Gottfredson (1986). The ideas of these theories take the reciprocal person-environment match further, but are not yet empirically verifiable (Roe) or apply only for a specific occupational field (Gottfredson). Nevertheless, Roe's and Gottfredson’s theories offer valuable insights into the factors influencing vocational interests at both the individual and social levels, including intellect, cognitive characteristics, social desirability, and cultural influences.

Anne Roe took an alternative approach to analysing vocational behaviour by using a psychodynamic perspective. Her primary research area was the development of the parent-child relationship. During this time, she discovered that the parents’ opinions, parents’ behaviour and the children’s interpersonal needs significantly influence the children’s occupational choices. She analysed which physical, psychological, and social factors affect career choice. Roe’s theory highlighted the importance of previous experiences (in particular the parent-child relationship) as an important aspect in the development of vocational interest. Additionally, she structured the occupations in the United States into eight groups with six sublevels each. The main vocational groups are (Roe, 1956):

1. Service,
2. Business Contact,
3. Organisation,
4. Technology,
5. Outdoor,
6. Science,

7. General Culture,
8. and Arts and Entertainment.

The sublevels range from level 1 'professional and managerial' to level 6 'unskilled'. According to her theory, individual differences in vocational interests are based on individual experiences (such as the parent-child relationship), the timing of the emergence of basic needs and specific environmental conditions (Roe, 1956). Satisfaction and frustration determine the attention and motivation to a positive or negative direction of vocational interest (Roe & Lunneborg, 1990). However, because Roe's theory is difficult to apply in research and often misunderstood, it remains a controversial approach (Osipow, 1997).

Career decisions are shaped not only by prior experiences but also by individual skills and cognitive abilities. Linda S. Gottfredson, Professor Emerita of Educational Psychology at the University of Delaware, extensively explored this subject before establishing herself as a prominent researcher in the field of intelligence in the United States. Based on a data-driven aptitude classification system, Linda Gottfredson developed the *Occupational Aptitude Patterns Map* (OAP). 10,620 job titles of the US labor force served as a foundation for the categorisation of the occupations. 13 OAP clusters are defined within four functional work areas (Gottfredson, 1986):

1. Physical,
2. Bureaucratic,
3. Social and Economic,
4. and Artistic.

The groups vary according to the intellectual difficulty and the field of work activities. The data used to define the clusters also include interest ratings, but vocational interests were only one aspect of this complex theory. Further components are for example individual's intelligence and cognitive abilities (Gottfredson, 1986). The OAP serves as a career classification system that focusses on a person-occupation fit and job satisfaction. Since this theory is based on the American labour market, its applicability in other countries remains limited. One internationally recognised model that is independent of regional factors is John L. Holland's RIASEC model. It serves as a framework for career counselling practices worldwide. Due to its theoretical and practical relevance, it provides the basis upon which this dissertation is built.

Holland's RIASEC model

John L. Holland was an American psychologist who held academic positions at various institutions, including the Johns Hopkins University, and was active in career counselling settings. Throughout his career, he remained deeply committed to the development and refinement of his vocational theory, which he rigorously investigated and translated into practical applications through the creation of assessment instruments and counselling tools (Hansen & Jordan, 2023). John L. Holland's career choice theory is the most important framework firmly anchored in current career counselling around the world. It has an impressive number of empirical evidence in work and organisational psychology. Up to 200 studies address various aspects, such as the stability and validity of the model, as well as its hexagonal structure (Bergmann & Eder, 2019; Tarnai & Hartmann, 2016).

Holland's *RIASEC model* combines hypotheses from Parsons' *Person-Environment Matching* and Super's *Life-Space Theory*. As previous career choice models were very complex, Holland's goal was to develop a simple theory, so that it could be easily verified and applied in career counselling. Interests, competencies, values, preferred activities, and biological heredity serve as attributes for the personality development and the career decision. The classification of these factors creates specific characteristic dispositions. Dispositions are types of vocational interest that include certain behaviour, distinctive skills, and unique attitudes of individuals. Each type deals with environmental challenges in a different way and has specific talents and abilities. The individuals select and process information according to their interest and the context. Occupational environments and vocational interests are divided into six dimensions, called *RIASEC types*: Realistic, Investigative, Artistic, Conventional, Enterprising, and Social. The aim of the theory is to match the person type with a corresponding work environment. These pairings can prognosticate educational and career choices, vocational interest stability, competencies, social behaviour, and proneness to external influences (Holland, 1997).

The following sections provide an overview of the RIASEC types with their different features and personality attributes.

Realistic types prefer work, like shaping materials with tools and machines, which requires dexterity, strength, and coordination. They develop their skills in technical, mechanical, electronic, or agricultural fields. Persons of the Realistic type reject social or artistic professions (Bergmann & Eder, 2019).
Personality attributes: adapted, persistent, materialistic, and practical (Holland, 1985a).

Investigative types prefer creative, observational, and systematic work on physical, biological, or cultural tasks. They have a strong scientific interest and dislike social or repetitive work (Bergmann & Eder, 2019).
Personality attributes: analytical, independent, introspective, and rational (Holland, 1985a).

Artistic types prefer open, unstructured, and creative activities. They enjoy working expressively with materials, language, and people in areas such as music, art, acting,

or writing. They reject limited, monotonous, and orderly activities or processes (Bergmann & Eder, 2019).
Personality attributes: impulsively, idealistic, open, and independent (Holland, 1985a).

Social types prefer activities that involve close interaction with other people. These include caring for, providing for, supporting, and educating people. Ethics, helpfulness, and solidarity are important to them. Activities with machines or tools do not suit them (Bergmann & Eder, 2019).
Personality attributes: empathetic, cooperative, kind and responsible (Holland, 1985a).

Enterprising types are masters in convincing, leading, and manipulating. They pursue organisational, economic or political goals with their activities. They prefer to work in leadership positions or in management. Systematic or observational tasks do not suit them (Bergmann & Eder, 2019).
Personality attributes: ambitious, talkative, self-confident, and energetic (Holland, 1985a).

Conventional types love the systematic handling of data, documents, records, and materials. They work in a structured and orderly manner. They like to apply their skills in computational, administrative, or business activities. Open and unstructured tasks overwhelm them (Bergmann & Eder, 2019).
Personality attributes: conscientious, thorough, practical, and thrifty (Holland, 1985a).

Individuals are defined not only by one personality type but by the interaction of the different types with each other. Thus, Holland created the RIASEC-code, which consists of three dimensions, for example, RIS (**R**ealistic, **I**nvestigative**,** and **S**ocial). The letter order is the result of the three most dominant RIASEC types.

Holland did not just define six vocational interest dimensions, he also related them to each other. A hexagonal model represents the structure and links between the six dimensions (see Figure 1). The dimensions, which are next to each other, have great similarity resp. psychological resemblance to each other. The dimensions which are vis-à-vis, are opposites to each other. For example: people who identify most with the Realistic type like activities with machines or systems rather than working together with other people. Opposite the Realistic dimension is the Social dimension, which include persons who want to work closely with other people. The hexagonal model serves as a verification of the RIASEC code consistency (high consistency: all three dimensions are next two each other / low consistency: two or more dimensions are opposite to each other). The same applies to work environments. Therefore, the congruence of person and environment can be checked with the hexagonal model (for instance: most congruent: Realistic person in a Realistic environment / most incongruent: Realistic person in a Social environment) (Holland, 1997).

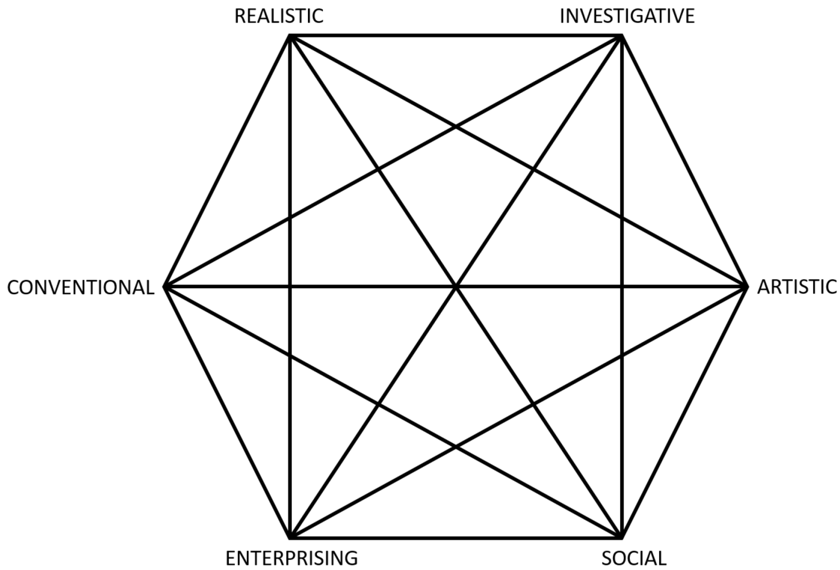


Figure 1: Hexagonal representation of the six RIASEC types (cf. Holland, 1997)

As the validity and reliability of the RIASEC model itself is scientifically proven, the hexagonal structure of the model is discussed critically (Tracey & Rounds, 1993). Various visual concepts are describing the RIASEC types within persons: a two-dimensional circumplex or quasi-circumplex (with unequal distances between the types) (Guttman, 1954); a misshapen polygon (also with unequal distances between the types) (Holland & Gottfredson, 1992), a hierarchical structure (see Figure 2) (Gati, 1979; Tracey & Rounds, 1993) or a spherical representation (Tracey & Rounds, 1996).

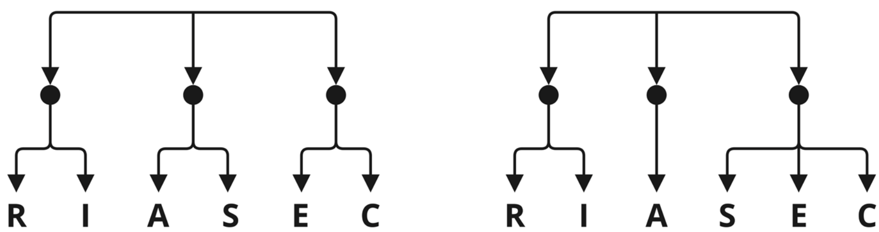


Figure 2: Left: Gati's hierarchical model / right: hierachical model of Rounds and Tracey. The top-down processes of career decisions are depicted by arrows (cf. Nagy et al., 2010)

The hierarchical representations are based on the assumption that two or more RIASEC types are paired. For example, Enterprise and Conventional show a higher correlation than Enterprise and Social; but there are still no studies on the specific patterns between the pairs. The pairs can theoretically be defined as higher-order domains, which share various features with each other. In the career decision process, individuals first choose one pair and then one of the specific RIASEC types (Gati, 1998; Nagy et al., 2010; Rounds & Tracey, 1996).

Regardless of which representation is used, the Holland model serves as the theoretical basis for several vocational interest tests. No other framework focusses on the interest features, information processing, and environment interaction as much as the Holland theory.

1.1.2 Career choice certainty

In addition to analyse the strength of vocational interests, it is also worthwhile to explore the extent to which young individuals feel certain about their career choices. This factor provides insight into the extent to which adolescents have advanced in their career decision-making process, as well as the degree of guidance and support they may still require to make informed and confident choices. Similar to the assessment of vocational interests, the evaluation of career choice certainty typically relies on standardised self-report measures (Al-Kalbani & Salleh, 2010; Osipow, 1999; Xu & Bhang, 2019). However, to address the known limitations associated with self-reported data, this dissertation also incorporates behaviour-based assessment tools to measure career choice certainty. The following section offers a concise overview of the broader field of decision certainty, with a particular focus on its application within the career context.

Career choice can be conceptualised as a specialised domain within the field of decision-making. As such, theoretical frameworks and empirical findings from decision-making research are directly applicable to understanding career-related decisions.

From a psychological perspective, decision-making is a cognitive and affective process through which individuals gather, evaluate, and structure information relevant to a particular issue or context. This process facilitates the identification of potential alternatives and supports the selection of one or more preferred options. In the context of career choice, individuals actively engage in acquiring and organising information about various occupational paths that align with their interests, values, and competencies. This evaluative process informs their selection of a suitable profession. Importantly, career choice is not a singular event confined to adolescence; rather, it represents a dynamic component of lifelong career development, subject to ongoing reflection and adaptation across different life stages (Harren, 1979; Holland, 1985a; Super, 1980).

For many years, career choice has been examined predominantly through a rational and conscious lens, emphasising deliberate decision-making processes and logical reasoning (Pitz & Harren, 1980). Consequently, the underlying cognitive processes involved in career decision-making have been the focus of extensive research. In recent years, however, there has been a growing recognition of the role of intuitive and unconscious mechanisms. Some scholars even argue that career decisions are driven primarily by non-cognitive factors (Krieshok et al., 2009). The distinction between rational and intuitive processes gives rise to different decision-making styles. These styles reflect characteristic patterns through which individuals perceive, interpret, and respond to decision-related situations (Harren, 1979). There are varying perspectives on how decision-making styles are categorised. One perspective views them as stable personality traits that consistently influence how individuals approach and navigate the decision-making process (Harren, 1979). They can also be conceptualised as learned, habit-based response patterns that are activated and employed in specific decision-making contexts (Scott & Bruce, 1995). These learned responses to decision problems are of particular relevance to this doctoral thesis. Eye tracking, as a method for analysing vocational interests and decision certainty, helps to bypass routinised decision patterns that individuals may exhibit in traditional assessment formats, such as extreme response styles in questionnaires. By emphasising behaviour-based decision-making, this approach fosters the activation of intuitive processes, offering a more nuanced understanding of underlying decision dynamics.

1.1.3 Assessment of vocational interest and career choice certainty

Theory-driven research necessitates a corresponding methodological approach. A range of assessment tools exists for evaluating both vocational interests and career choice certainty, which will be briefly outlined in the following sections. Particular emphasis is placed on instruments grounded in the RIASEC model for assessing vocational interests.

The assessment of vocational interest is a key part of the career counselling process. Thus, career counsellors can use a couple of test inventories to analyse the individual's occupational preferences. These inventories are based on and tested with several empirical studies. Previous research in vocational interest focused on cross-sectional methodology for obtaining an overview of the current occupational trends (Mudhar et al., 2020); or longitudinal studies which analysed the development of individual or the societies vocational interests over time as well as the factors that influence them (Ertl et al., 2023; Pässler & Hell, 2020).

A broad spectrum of instruments, ranging from traditional inventories to innovative assessment methods, are used to measure vocational interests. The most widespread method is self-reports, which rely on Holland's RIASEC model. Starting with Holland, who developed the *Self-Directed Search* (SDS) as a supplement to his theoretical model, many inventories followed (Holland, 1985b). In Germany, the EXPLORIX® (Singer et al., 2007) and the AIST-3 (Allgemeiner-Interessen-Struktur-Test) (Bergmann & Eder, 2019) are widely used in career counselling. Both are based on the RIASEC model. The EXPLORIX® is the German adaptation of the SDS, which young people can carry out by themselves (Singer et al., 2007). The AIST-3 is an extension of the SDS, which requires professional counsellors to guide the young people through the questionnaire (Bergmann & Eder, 2019).

For the present doctor thesis, the AIST-3 was chosen as a measure of the strength of vocational interests. The AIST-3 takes into account cognitive, emotional and personal values. It has been used in German career counselling for over 10 years. The self-assessed vocational preferences are determined using a questionnaire. The 60 items consist of explanations of occupational activities, which are rated on a 5-point Likert scale (free-choice format) by the participants. The scale ranges from 1='I am not interested at all' to 5='I am very interested' (Bergmann & Eder, 2019).

Examples for the item formulations are (Bergmann & Eder, 2019):

- **Realistic:** 'working with machines and technical devices'
- **Investigative:** 'performing experiments in a test laboratory'
- **Artistic:** 'writing stories or reports'
- **Social:** 'looking after or caring for other people'
- **Enterprising:** 'leading a team at work'
- **Conventional:** 'keeping accounting records'

The internal consistency of the item scores ranges from 0.86 to 0.90; the one-month stability varies between 0.87 and 0.92 for each dimension. Validity tests were carried out, which addressed the internal validity, the differential validity (e. g., gender differences and school types), and the person-environment congruence. To assess the primary vocational interest dimensions, the RIASEC code (three-letter code) is generated. Therefore, raw values are converted into standard values. The standard values are fitted into the hexagonal chart to generate a visual interest profile of the individual (Bergmann & Eder, 2019).

Assessment tools are not limited to distinct career decisions. Career indecision is analysed from a theoretical or a data-based approach (Osipow, 1999). The *Career Decision Difficulties Questionnaire* (CDDQ) is an example of a theoretical-based inventory. In the CDDQ, the rational cognitive processes of general decision-making theories were adapted to the career choice process. Its multidimensional approach is based on three reasons for indecisiveness: insufficient knowledge of professions, inconsistent information about occupational opportunities, and developmental deficits (Gati et al., 1996). On the other hand, data-driven approaches on career (in)decision are made from empirical sources. The *Career Decision Scale* (CDS) is a unidimensional questionnaire, which was used first as a diagnostic tool to assess differential treatments (Osipow, 1999). The *Career Factors Inventory* (CFI) is a multidimensional, dichotomous model. It states that career certainty needs sufficient information about occupational environments and activities as well as individuals' self-confidence (Chartrand et al., 1990).

Both vocational interest tests and career decision inventories use scale-based self-reports. Despite decades of research with self-reports and scale-based questionnaires, the general criticism of these methods increases. Criticism has been raised concerning potential biases in participants' answers self-reported feelings, reactions, and decisions (Holt & Laury, 2002; Wilson & Gilbert, 2003). Problematic aspects are participants' tendencies to extreme or moderate responses (Aichholzer, 2013; Newcomb et al., 1986); or the proneness to socially preferred answers (Larson, 2019; Nederhof, 1985). Due to sociocultural changes and technological progress, new problems arise that can change the quality of the results of self-assessment tools. For example, all of these inventories are language-dependent. Text-based tests pose comprehension problems for non-native speakers and for native speakers with language comprehension problems. This barrier is a significant challenge within an effective career guidance process. Furthermore, questionnaires encourage arbitrary and subjective responses. They often ask for the self-assessed preferences of the participants. Parents and their families have a decisive influence on the career choice of young adults (Bregman & Killen, 1999; Vautero et al., 2021). Therefore, adolescents can declare vocational interests that do not correspond to their own interests. Another limitation adresses the large number of test items (≥ 60 items). Participants must keep their attention and motivation high for a long time. Without attention and motivation, the results are inconclusive and nonrepresentative. This has a direct impact on reliability and validity (Süß & Schmiedek, 2000). The established vocational interest inventories have no *Instructional Manipulation Checks* (IMCs) (Oppenheimer et al., 2009) or control questions, which could verify the data. This can lead to incorrect estimates of test effects. To avoid such distortions, an involuntary and expeditious measurement for vocational interest and career choice certainty is needed.

Having demonstrated the diverse nature of research on vocational interest and career choice certainty, the following section will now focus more closely on the second main research field of this thesis: the individuality of eye movement behaviour.

1.2 Individual differences in eye movement behaviour

In addition to individual differences in personality traits, humans also exhibit variability in visual perception. Visual perception is a unique process, with eye movements playing a crucial role. Humans focus, select, and evaluate what they see in various ways, influenced by external environments or intrinsic states. The following sections explore key aspects of this variability, focusing on eye movements, attentional control, and information processing. This overview lays the basis for the central assumption of this doctoral thesis: that eye movements are not only integral to perceptual processes but also reflect underlying psychological characteristics, like personality traits. The final section addresses the domain of decision-making. Existing research has demonstrated meaningful associations between eye movement patterns and cognitive processes involved in decision-making, highlighting the relevance of gaze behaviour in understanding how individuals evaluate and choose between options.

1.2.1 Characteristics of visual attention

Eye movements serve as a central focus in this thesis. To gain a more comprehensive understanding of their underlying mechanisms, it is appropriate to begin at a broader level by examining the fundamental characteristics of visual attention, which influence oculomotor behaviour.

Visual attention is defined as an individual unconsciously selection of relevant information from a large amount of perceived information (Itti et al., 1998). Current theories of visual attention emphasise that visual attention is guided by two different information processes: bottom-up control and top-down control. Bottom-up processing refers to a stimulus- or data-driven approach through which the brain processes incoming information. This mechanism is initiated by external stimuli, such as contrasts, colours, brightness, etc., that activate visual receptors in the eye. In contrast, top-down processing is a knowledge-based processing and relies on pre-existing knowledge (stored in the short-term and long-term memory) to interpret and analyse sensory information. Usually, both processes are leading the perception, but in some cases (for example, looking at a bright beam of light) only bottom-up control takes over. The more complex and detailed external stimuli are, the more top-down control is involved in the visual perception (Goldstein & Gegenfurtner, 2015; Neisser, 1976).

Eye movements are strongly linked to visual attention and according to Rizzolatti et al. (1994), attentional relocation is a by-product of a planned eye movement to a specific position in a scene. In addition, current research supports the notion that eye movements and the focus of attention do not always match 1:1. The allocation of visual attention is also expressed by the saccade latency and saccade trajectory. Time is an important factor here. Early oculomotor selection is guided by bottom-up processes; followed by a phase of recurrent processing, which is influenced by top-down control (van der Stigchel et al., 2009; van der Stigchel & Theeuwes, 2005). For example: when an individual is viewing an image for the first time, initially it orientates on colours, shapes, contrasts, etc. Then–if there is a specific search task–top-down control guides the attention to places that provide relevant information for the fulfilment of the task.

For bottom-up processing, visual salience plays an important role. Visual attention is unconsciously shifting from one position to another due to the salience of the stimulus. Conspicuous features such as colours, shapes, movements, brightness, or orientations trigger this change of attention (Anderson et al., 2011). The most influential parameter is the contrast of local features. Thus, significant salience occurs when an object varies in one or more features from nearby objects or the background (Fecteau & Munoz, 2006). To analyse potential bottom-up influences on visual attention, salience maps are used. These topographically arranged maps represent regions of interest (ROI) that may attract individuals' visual attention (Itti et al., 1998). Salience plays a decisive role in eye movement behaviour, especially during free exploration. To minimise potential biases introduced by design features in the doctoral studies, salience maps of the stimuli were created. This approach was intended to ensure that search behaviour was primarily guided by top-down processes.

Salience has a limited influence on attention in a task-related visual search (Polatsek et al., 2018), because task-related visual attention is based on top-down processing. Previous knowledge, personality traits, intentions, and specific goals can drive the attention to regions of interest that are relevant for information processing and the resulting behaviour (Goldstein & Gegenfurtner, 2015). Alfred Yarbus first reported on the difference in eye movement patterns and visual attention when individuals were given specific search tasks (Yarbus, 1967). Since then, much research has been done on influence of tasks on the viewing behaviour. Empirical studies focused primarily on cognitive and neurophysiological aspects (Noudoost et al., 2010; Paneri & Gregoriou, 2017; Thompson & Bichot, 2005) as well as psychological and behavioural topics (Haji-Abolhassani & Clark, 2014; Mills et al., 2011; Treisman & Schmidt, 1982).

One relevant concept for top-down and bottom-up processing is the visual search. Individuals carry out visual search processes in everyday life, for example when someone tries to find his friend in a crowded place. Visual search is the procedure to find a target among irrelevant distractors. In the three studies of this doctoral thesis, participants conducted a visual search on images to find an occupational scene that matches their vocational interests. Hereby, top-down control, in particular, should guide the visual exploration. The literature distinguishes visual search in two different types: feature search and conjunction search (Treisman & Gelade, 1980). In feature search, there is one characteristic that distinguishes an object from others; for example, a black ball between red balls. In conjunction search, the target has more than one feature that separates it from distractors; for example, a lawyer in the court-room and police officers at the police station (van der Stigchel et al., 2009). In the present doctoral work, participants had to perform a conjunction search. They had to search for their favourite profession among various occupational representations. Each occupational activity came with specific features (such as the workwear, the workplace and the work equipment) that differentiated the scenes from each other.

As noted earlier, top-down control plays a crucial role in conjunction search; in the context of this thesis, vocational interests are expected to direct eye movements. The next scection provides an overview of the areas in which eye tracking has already been used to detect individual differences and mental states.

1.2.2 Influence of personality and mental states on eye movements

Past studies provided empirical evidence of the strong link between eye movements and personality traits, as well as the mental state (Bargary et al., 2017; Berkovsky et al., 2019; Hoppe et al., 2018; Tarnowski et al., 2020). For example, personality traits such as Conscientiousness, Agreeableness and Neuroticism of the *Big Five Inventory* can predict visual search behaviour (Biggs et al., 2017; Le Bras et al., 2024). Sarsam et al. (2023) demonstrated that fixation duration, fixation count, and pupil diameter in response to facial images vary systematically as a function of specific personality traits, such as Neuroticism, Agreeableness, and Conscientiousness. Individuals sharing similar personality characteristics tend to exhibit comparable eye movement patterns, suggesting a consistent relationship between personality and visual attention.

In addition to personality traits, mental states can also be determined via eye tracking. The work of Gere et al. (2017) demonstrates that positive and negative moods influence eye movement behaviour. Positive mood manifests itself in longer fixation duration and dwell duration as well as a higher number of fixation counts and dwell counts. When choosing between several options, people in negative mood tended to take less time for their decision (Gere et al., 2017). Alshehri and Alghowinem (2013) reported that positive and negative emotional states can be assessed with the analysis of the fixation duration and fixation count (Alshehri & Alghowinem, 2013). Beyond that, eye tracking can be used to categorise emotional states via pupil diameter (Tarnowski et al., 2020). These objective methods can circumvent potential biases through subjective self-reports of the participants (Tarnowski et al., 2020). The mentioned aspects indicate that the eyes are not only a physical part of our body, but also a reflection of individual personality characteristics and mental states.

1.2.3 Eye movement behaviour and choice certainty

The final sections address the choice certainty. In this context, visual search and top-down processing play a significant role. Decision certainty is a crucial aspect of career choice, as it provides an indication of how far adolescents have progressed in their career decision-making process.

When analysing choice certainty, endpoint measurements like response times and self-reports of the chosen options are common parameters (Treisman & Gelade, 1980; Wolfe, 1998). These variables are valuable but cannot provide information on the underlying cognitive processes of decision making (Sanders & Donk, 1996). In contrast to this, eye movements can reflect perceptual, cognitive, and evaluative processes (Findlay & Gilchrist, 1998). Eye tracking is a direct and real-time method for decision modelling and has a long history (Berlyne, 1971; Yarbus, 1967). There is a growing line of research in the assessment of suitable parameters, which can predict individuals' decision (un)certainty. Especially in the field of economics and artificial intelligence, the significance of behaviour-based parameters for the investigation of preferred options or decision certainty is becoming increasingly important.

According to Eckstein (2011) visual search is one paradigm that is used to study perceptual decision processes. Thereby, various options are presented, which force the observer to scan the image and settle on a response for specific information. Eye movements unveil the observers' search patterns and their search time. Depending on which target one fixates, salience as well as information about the task and target can be revealed (Eckstein, 2011). The oculomotor system balances between salience (bottom-up control) and internal values (top-down control) in the decision on where to look next (Meeter et al., 2010).

There is a growing body of research that provides empirical evidence supporting the relationship between fixation patterns, saccadic behaviour, pupil diameter, gaze shifts, and decision certainty (Brunyé & Gardony, 2017; Horstmann et al., 2009; Uggeldahl et al., 2016). For example, long dwell times on the preferred option and a high number of refixations towards the favourite alternative indicate decision certainty. Additionally, a long fixation time on the favoured option is evidence of high decision-making reliability (Glaholt & Reingold, 2011; Rojas et al., 2020; Saito et al., 2017). Depending on the difficulty of the decision task and the complexity of the stimulus, observers reduce the overall number of fixations and saccade length in order to be able to execute a decision and to reduce the working memory load (Orquin & Mueller Loose, 2013). Stimuli with high salience and complex design are triggering refixations. To reduce a perceptual uncertainty, observers shift between novel objects (exploration) and earlier fixated objects (exploitation) (Spering, 2022). According to the *Gaze Cascade Mode*l by Shimojo et al. (2003), decision-makers fixate their preferred option right before they verbally communicate their decision. This phenomenon appears within various stimuli, like shapes and faces. Therefore, eye movements can predict decision-making behaviour and also contribute to the decision-making process (Shimojo et al., 2003; Spering, 2022).

In summary, this doctoral thesis emphasises the role of top-down processing in visual perception. The central objective is to investigate whether individual interests function as a top-down mechanism guiding visual attention. Visual salience is important in the design of image stimuli to ensure that visual features do not disproportionately capture attention, thereby minimising the influence of bottom-up control on the perception of the images. The conjunction search paradigm is proposed as a method for assessing vocational interests by requiring participants to select a profession from a set of alternatives. Empirical evidence supports the theoretical plausibility of this approach. Previous research has demonstrated correlations between personality traits and eye movement metrics, such as fixation frequency and dwell time. Additionally, the Gaze Cascade Model provides further support by showing that individuals tend to increasingly fixate on their chosen option prior to articulating a decision, reflecting the dynamic interplay between gaze behaviour and preference formation.

1.3 Vocational interest and visual perception

Building on the overview of the two central research areas of this thesis, the following section integrates these fields. Current research and practices in career counselling increasingly demonstrate the use of perception-based approaches to assess vocational interests and identify possible career paths. These developments provide a valuable empirical foundation for validating the findings of this doctoral research. The relationship between interests and attentional processes, initially introduced in Section 1.1, is now explored in greater depth. In this context, existing perception-based instruments for assessing vocational interests are reviewed, highlighting the design of the image stimuli and test specifications. First, the origin of the relationship between vocational interests and visual attention will be reviewed.

At the beginning of the 20th century, Frank Parsons recognised the connection between professions and visual perception in one of his unpublished manuscripts (Parsons, n.d.):

'If a farmer, an artist, an architect, and an entomologist are walking together, the farmer will see all the trees and corps, the artist will see the beautiful women, the clouds, the sky and the scenery, the architect will see the buildings and note their excellencies, and their defects, and the entomologist will see all the bugs. Why is it that each man notes a different class of facts? It is because the dominant interests are different. [...] It is the result of a large accumulation of impressions relating to some subject of thought or method of action. [...] These dominant interests or masses of impressions in the brain control in large degree our thoughts, our emotions and our actions, and these interests we can shape and develop as we will.'

At the end of the 20th century John L. Holland took up this topic and incorporated it in his theory (Holland, 1997):

These events-an increasing differentiation of preferred activities, interests, competencies, and values-create a characteristic disposition or personality type that is predisposed to exhibit characteristic behavior and to develop characteristic personality traits, attitudes, and behaviors that, in turn, form collections of skills and coping mechanisms that include the following:

- *[...]*
- *Perception of the environment*
- *[...]*
- *Preferences of occupations and occupational roles*
- *[...]'*

Parsons and Holland have addressed an important topic that has not received much research interest in the past. Visual perception and interest have always been linked. Interest is considered as a motivational component which is related to the SEEKING system. It is a genetically and evolutionary anchored emotional brain system that is linked to visual perception (Hidi, 2006; Panksepp, 2005). In previous studies on visual perception, visual attention was a main object of research. It turned out that visual attention is the expression of individuals' interests (Krapp, 1992). Even though, an increased interest does not always mean an increased attention (McDaniel et al., 2000). The literature indicates that interest and attention are distinct constructs, as are visual attention and eye movements–highlighting that these processes do not always align, as discussed above. Thus, analysing the link between cognitive processing of interest and motor activation (eye movements) is worthwhile. This doctoral thesis should help to close the research gap, so that the relationship between interest and eye movement behaviour is better understood. The following sections provide a short overview of the current state of research on the link between interest, visual attention, and eye movements.

1.3.1 Perceptual determination of interest, curiosity, and expertise

Proponents of the biological roots of visual perception and interest include Langsdorf et al. (1983), who demonstrated a linear relationship between interest duration and fixation time among 2- to 8-month-old infants (Langsdorf et al., 1983). Additionally, there is a difference in interest expression while observing interesting and non-interesting stimuli. A sustained visual attention on images or micro-videos manifests itself in longer saccades (Soleymani & Mortillaro, 2018). Research in perception-based image processing showed that overt visual attention (in form of fixation patterns) and perceived interest (in form of consciously selected image regions) strongly correlate with each other. As a result, regions of interest are predictable through eye gaze patterns (Engelke & Le Callet, 2015). At this point, Paul J. Silvia must be mentioned, who has devoted himself to research on the structure, impact, and effects of individual interest. One of his studies analysed the appraisal structure of interest using visual stimuli such as random polygons, visual art, and poetry. The findings revealed a strong connection between interest and the number of fixations, fixation duration, and saccade length. Furthermore, Silvia argues that it is possible to detect interests but not enjoyment with eye movement analysis (Silvia, 2005).

Following from this, a line of research has established the distinction between interest, curiosity, and enjoyment. The concept of interest is interpreted differently across research disciplines. In the present thesis, interest is conceptualised within the framework of the person-object theory of interest, which defines interest as a relational construct between an individual and an object, giving rise to a relatively enduring predisposition (Hidi & Renninger, 2006; Krapp, 1992). Interest is linked to cognitive processes such as exploration, attention, and learning (Tomkins, 1962). One aspect of interest is curiosity, which emerges from a perceived information gap. Curiosity motivates an individual to engage–potentially repeatedly–with the object of interest in pursuit of novel information (Berlyne, 1966). Whereas both interest and curiosity are characterised as relatively sustained motivational-affective states, enjoyment is understood as a temporary affective experience that arises specifically during engagement with a desirable and intrinsically rewarding activity. This engagement is accompanied by positive affect and a subjective sense of goal fulfilment (Smith et al., 2014). Both interest and curiosity have been empirically associated with patterns of eye movement behaviour, whereas enjoyment does not appear to exhibit such a relationship. For example, the viewing time of images is linked to self-reported situational interest (Berlyne, 1971). Risko et al. (2012) investigated the relationship between gaze patterns and personality traits. They found evidence that the number of perceived image regions correlates with the *Perceptual Curiosity Scales* (Collins et al., 2004; Risko et al., 2012).

Furthermore, there is a connection between eye movement behaviour and occupational aspects. A meta-analysis of Gegenfurtner et al. (2011) investigated the eye movement behaviour of experts and non-experts in various domains (medicine, sports, public transportation, etc.). The stimuli presented in the examined studies were static and dynamic, and there were different task-specific variables (time on task, complexity, etc.). They found a general agreement of differences in viewing behaviour between experts, intermediates, and novices. Expert eye movements exhibited shorter fixation duration, longer saccades, and a quicker first fixation on relevant information. Non-experts focussed on more task-irrelevant objects than the experts (Gegenfurtner et al., 2011). Papesh et al. (2021) claimed that an increasing expertise reduces the probabilities of fixations and fixation durations, whereas the saccade amplitude and the visual span rises (Papesh et al., 2021). The different eye movement behaviour of experts and non-experts appears also in the interpretation of visual arts. People, who have a higher appreciation for paintings with balanced compositions (experts) and people, who do not (non-experts), altered in the dwell time, fixation duration, and fixation count (Francuz et al., 2018). These deviation in visualisation comprehension have a great influence on domain-specific learning. The learning content has to be presented differently depending on how the individuals process the information. This could be helpful in improving the methods used in vocational training. Furthermore, specific visual search skills and gaze behaviour are important for particular occupations (Gegenfurtner et al., 2011). For example, a security guard needs an efficient visual search behaviour to find potentially violent people or a tram driver has to rapidly examine a hazardous situation on the street. Besides the level of expertise, skills and abilities can also be determined with eye movement analysis. In medicine, skills in nursing, anaesthesia, radiology, surgery, and general diagnostic are correlated with specific visual patterns (Harezlak & Kasprowski, 2018).

The approach of assessing decision certainty through eye movement analysis is not novel, too. Recent advancements in psychometrics, cognitive research, and decision modeling have consistently demonstrated a strong correlation between eye movement patterns and levels of decision (un)certainty. When individuals are confident in their choices, they tend to exhibit longer and more focused fixations on specific regions of interest. In such cases, fixation durations increase, while the overall number of fixations decreases. Additionally, saccadic movements become slower, and individuals are more likely to repeatedly direct their gaze toward the preferred option (Brunyé & Gardony, 2017; Uggeldahl et al., 2016). This phenomenon is known as the gaze bias effect, a central concept in the field of visual decision-making (Saito et al., 2017; Shimojo et al., 2003). The studies conducted thus far have primarily focused on decisions involving products, shapes, or images–choices that typically do not carry long-term implications for participants' satisfaction or quality of life. However, it is of particular interest to explore whether similar visual attention patterns, including the gaze bias effect, can also be observed in high-stakes decisions with enduring consequences, such as career choices. Investigating this could provide valuable insights into the cognitive and affective processes underlying complex, life-shaping decisions.

1.3.2 Perception-based vocational interest tests

Perceptual assessments are already used in career counselling with nonverbal measurements. Image-based methods offer a helpful alternative approach to scale-based inventories, especially for adolescents who struggle with reading and writing. These tests analyse vocational interests via images, pictograms, or realistic photographs.

The procedures range from digital image evaluation using smiling or sad emojis to card sorting with real photo cards. The images have the advantage of telling a whole occupational work story (story telling). The stimuli visualise how the labourers are working together in specific work environments. According to Geist & McDaniel (1952) less ambiguity should provoke high reliability and validity, which makes perception-based tests an alternative to scale-based inventories. Visual stimuli offer less room for interpretation than scale-based tests, as they represent the work activities exactly. However, the distinct principles underlying mental representation in image-based versus scale-based assessments must be considered.

According to Palmer (1978) and Schnotz and Bannert (1999), images function as depictive (intrinsic) representations, whereas texts serve as descriptive (extrinsic) representations. Depictive representations enable the portrayal of specific features, such as detailed workflows, while descriptive representations facilitate the communication of broader, more abstract domains, such as occupational fields. Due to their direct depiction of reality, image-based measures face inherent limitations in assessing overarching vocational interests. For instance, a participant may reject images depicting office-related tasks, despite the fact that many professions incorporate office work as only one component of a more diverse role. A forest ranger, for example, may engage in office-based planning in addition to fieldwork. Accurately capturing such multifaceted roles through imagery would require presenting multiple images, which participants would need to prioritise to reflect their preferences adequately. In contrast, text-based assessments can convey these complex role characteristics more efficiently through verbal descriptions. Nevertheless, image-based assessments offer unique advantages, including the capacity to evoke emotional responses, activate memories, and elicit spontaneous preference judgments from participants. Perception-based assessments are language-independent, so people with different mother-tongues can attend. The following sections introduce a selection of popular nonverbal test inventories.

First, assessments with illustrated images are presented. The *Reading-Free Vocational Interest Inventory R-FVII-R* of Becker (1981) consists of 80 colour images. The careers are categorised into the 16 career clusters of the U.S. Department of Education and the U.S. Department of Labor and People, Data and Things. Participants need 15 to 30 minutes to choose their favourite occupation among three simultaneously presented pictures. The test is suitable for adolescents from the 5th grad up to adults and is carried out with pen and paper or via online platform. The test-retest reliability ranges from 0.63 to 0.87 and the equivalency coefficients range from 0.79 to 0.89 (Becker, 1981). Another test that uses illustrations is the *Geist Picture Interest Inventory GPII-R* (Geist, 1964). In contrast to the R-FVII-R, the GPII-R uses black and white images. An advantage of these stimuli is the reduced bottom-up influences (like colours and contrasts) on the decision making. The items cover twelve female and eleven male interest dimensions. Like in R-FVII-R, participants have to choose a preferred preference among the three depicted occupations. Adolescents from 8th grade up to adults can carry out the pen and paper test. The selection procedure can be supplemented with a self-reported motivation scale for a comprehensive analysis of participants' career choices. This widely used inventory has a broad empirical base on test-retest reliability and validity within various cultural and educational backgrounds (Geist, 1964).

Another career choice tool is the *Iconographic Professional Interests Inventory 3IP* of Boerchi and Magnano (2015). The test consists of strongly reduced stimuli that exclude essential features such as colours, faces, and gender-specific factors. This approach was chosen to prevent bias through stereotypes and physical attractiveness of the portrayed persons. The stimuli are 65 black and white pictograms that are categorised into 19 dimensions. The self-assessment tool addresses children, young students, and foreign students (age between 9-13), who have limited language skills.

Besides illustrations and iconographic images, there are perception-based tests that use realistic photographs as stimuli. The *Nonverbal Vocational Interest Scale NVIS* of Weißmann et al. (2022) is a relatively new self-assessment tool that includes 138 realistic photographs of occupational activities. It was developed for adolescents at the beginning of the vocational orientation and for young adults who have to reorient themselves because they quit a previous apprenticeship. The test authors aimed to reduce the complexity of the stimuli and therefore the photographs represent only one activity in a close-up shot (Nurcahyo et al., 2019). Like the 3IP of Boerchi and Magnano (2015) the NVIS tend to reduce influences of stereotypes and attractiveness. The NVIS is based on a model similar to the nine-dimensional model of Egloff & Jungo (2012). Participants rate the items with a 3-point scale, that consists of different emojis. The smileys have various colours: red for no interest at all, yellow for moderate interest, and green for high interest. The scales have an internal consistency of 0.80 to 0.90 and a validity of 0.30 to 0.50 (against the F-I-T, see below).

A test that determines vocational interest with photographs is the Swiss F-I-T (Foto-Interessen-Test) of Jungo and Toggweiler (2019). The F-I-T is based on the RIASEC model of Holland (1997) and the nine fields of vocational interest according to Egloff, E., & Jungo, D. (2012). The test is performed online or with physical cards and is suitable for adolescents aged 14 and older, as well as adults. The stimuli consist of 125 realistic photographs that represent occupational activities and work environments. The test procedure takes 10 to 20 minutes per participant. The photos are updated every two years. In contrast to the NVIS, the photographs of the F-I-T show people in a half-length or half-close-up perspective so that features like faces, genders, and emotions are clearly visible. Participants rate the different photos on a 3-point scale (no interest at all, moderate interest, high interest). Afterwards, the cards with moderate and high interest are sorted into groups, and these categories are named individually. The results are interpreted quantitatively or qualitatively. For the quantitative interpretation, stanine values are evaluated from standardised values according to the Egloff model or the Holland model. A qualitative interpretation is based on the selected cards of the participants (e.g., individual rankings). The F-I-T has a reported reliability of 0.72 to 0.94 for the Egloff model and 0.79 to 0.95 for the Holland model. The construct validity of the RIASEC dimensions of the F-I-T in comparison with the RIASEC dimensions of the AIST-R is on average 0.74. The F-I-T can be used on its own or as an addition to verbal inventories like the EXPLORIX® (Jungo & Toggweiler 2019).

Career counsellors today have access to a wide range of image-based assessment tools. These visual stimuli, ranging from realistic photographs and detailed close-ups to black-and-white illustrations, aim to represent vocational interests as accurately as possible. In the present doctoral dissertation, full-color illustrations presented in wide-angle views were selected. Colours and contrasts were deliberately chosen to support participants during conjunction search tasks, enhancing perceptual processing. Furthermore, the collaborative nature of work in the depicted professions was emphasised. To reflect this, the illustrations avoided close-ups and medium shots; instead, entire scenes were shown, including the broader work environment and relevant tools, to provide a holistic impression of the occupational context. The RIASEC model served as a helpful basis for creating the stimuli, because previous studies and several established test inventories have demonstrated that Holland's RIASEC theory is a reliable model to determine vocational interest. The RIASEC model has significantly contributed to supporting countless adolescents in their career guidance process. Its structure is simple and versatile and is adapted in various test designs, such as scale-based (AIST-3) and perceptual designs (F-I-T). This is the reason why this model was chosen for the doctoral thesis.

Advancements in technology now enable the development of career interest assessments utilising digital media, a progression that is particularly overdue for younger generations who have grown up in a media-rich environment. Integrating media-based assessments allows for a test design that aligns more closely with the natural context of the target population. In particular, eye tracking technology is undergoing significant advancements and is increasingly applied in various domains, including clinical diagnostics (Jiang et al., 2025; Merzon et al., 2022), gaming (Feng et al., 2024; Sundstedt, 2012), or user assistance systems (Apple Inc., 2024; Masnadi et al., 2020; Neogi et al., 2021). Consequently, it is an innovative approach to utilise eye tracking for a new career counselling tool.

1.4 Summary and doctoral research questions

The present thesis discusses the extent to which vocational interest and career choice certainty can be determined with perceptual measurements. The aim of this doctoral thesis is twofold. The first is to analyse possible eye tracking parameters for visual assessment of vocational interest. The underlying research question of this is the following: *Which eye movement metrics can reliably predict the strength of vocational interest in adolescence?* The second aim is to determine the career choice certainty with fixation and saccadic behaviour. The corresponding research question is: *Can the career choice certainty be analysed with direct measurements like eye movement behaviour?* The findings will be used to evaluate the degree to which behaviour-based measurement methods are suitable as alternatives to scale-based self-reports in career guidance. Care was taken to ensure that the new assessment methodology avoids typical problems of self-reports, such as social desirability and extreme response styles. Eye tracking was selected as a predictor because of its ability to measure independently of reading competencies. It offers the advantage of delivering reliable results in a matter of minutes. According to the current state of research, no other studies have looked specifically at the relationship between vocational interest and eye movement behaviour. This thesis tests previous findings of the behavioural measurement of personality traits and general interest and applies them to the specific use case of vocational interests.

2 Dissertation Overview

This chapter provides a comprehensive overview of the three empirical studies carried out for this doctoral thesis. It begins with a brief overview of the research objectives and methodologies employed. Subsequently, three manuscripts offer a detailed examination of the individual experiments.

Study 1

The first study aimed to evaluate the potential correlations between eye movement patterns and the strength of vocational interests. A distinctive feature of the methodology was the use of a complex visual stimulus, requiring participants to make an immediate decision regarding an occupational domain upon viewing the image. The design criteria for the image stimulus were established in a preliminary study. Based on a comprehensive literature review, three eye tracking parameters were selected as measurement variables: dwell time, fixation count, and time to first fixation, each assessed within six predefined areas of interest (AOIs). In addition to eye tracking data, the study incorporated a standardised vocational interest assessment (AIST-3) and an occupation-related evaluation of the AOIs. A total of 102 participants (mean age = 17.25 years) initially rated their vocational interests using the AIST-3 via the online platform Hogrefe Test System (HTS). They subsequently completed the eye tracking task, in which they viewed an image stimulus designed to represent the six RIASEC dimensions. Eye movement data were recorded using a remote eye tracker (SMI), with parameters analysed for each AOI. Finally, participants provided a subjective rating of their vocational interest in relation to each AOI.

The data analysis was based on linear regression models (simple and multilevel). The models were conducted using the software R. The results indicated significant correlations between vocational interest and eye movement behaviour in five of the six

RIASEC dimensions. The eye tracking parameters dwell time and fixation count were suitable to predict preferred RIASEC types.

Study 2

Study 2 was designed as an advancement of the first study, addressing methodological limitations and potential biases related to the test procedure. While Study 1 identified significant correlations between vocational interests and eye movement metrics, Study 2 refined the methodology to enhance the validity of these findings. Additionally, perceptual parameters were examined as potential predictors of career choice certainty. In Study 1, the Conventional RIASEC dimension did not yield significant effects. To address this, a revised AOI image for the Conventional category was developed, and six additional AOIs were incorporated into the eye tracking test. To mitigate potential priming effects, the test sequence was adjusted: the eye tracking task was conducted first, followed by the image rating and the AIST-3 assessment. 67 adolescents with a mean age of 16.66 years participated in Study 2. The study aimed to determine the strength of vocational interest and the career choice certainty using eye tracking data. Career choice certainty was measured by analysing saccadic behaviour and correlating it with response times in AIST-3 item responses.

The data was analysed using simple and multilevel linear regression models (software: R Studio). Consistent with the findings of Study 1, Study 2 confirmed significant correlations between vocational interest and both dwell time and fixation count–now across all six RIASEC types. Additionally, saccade count demonstrated a low but statistically significant predictive effect on career choice certainty.

Study 3

The objective of Study 3 was to conduct a detailed analysis of the career choice certainty. While Studies 1 and 2 identified suitable eye tracking parameters for measuring the strength of vocational interest, Study 3 focused on the perceptual assessment of career choice certainty. The test procedure from Study 2 was adapted and expanded to include two certainty assessments. One assessment evaluated career choice certainty based on AOI image ratings, while the other measured certainty in relation to AIST-3 item responses. Both evaluations utilised scale-based ratings. Additionally, response times of AIST-3 items were analysed to examine their correlation with the self-reported career choice certainty. Building on the findings of the previous studies, the eye tracking parameters AOI revisits, AOI fixation duration, saccade count, and saccade velocity were selected as potential predictors of career choice certainty during the observation of the two image stimuli from Study 2. A total of 148 data sets from participants with a mean age of 17.01 were used to run simple and multilevel linear regression models in R.

Contrary to our expectations, no significant relationships were found between eye movement metrics and career choice certainty. This applied to both response time as an indirect measure of certainty and the self-reported certainty ratings. However, a low but statistically significant correlation was observed between response time and self-reported certainty, as well as between the two certainty assessments (image-based and AIST-3-based). In contrast, an additional evaluation reaffirmed the relationship between self-reported vocational interest and both dwell time and fixation count, consistent with the Studies 1 and 2. In summary, the findings of Study 3 did not identify a reliable eye tracking parameter for assessing career choice certainty. However, they further validated dwell time and fixation count as robust indicators of vocational interest strength.

EBERHARD KARLS UNIVERSITÄT TÜBINGEN

Mathematisch-Naturwissenschaftliche Fakultät

Declaration according to § 5 Abs. 2 No. 8

of the PhD regulations of the Faculty of Science

-Collaborative Publications-

The following chapter (Chapter 2.1) consists of a manuscript that was co-authored by Stephan Schwan and Constance Richter.

The manuscript 'Relationship between eye movement behavior and vocational interests' is already published in the journal 'Personality and Individual Differences' of Elsevier (doi: 10.1016/j.paid.2024.112975).

The proportional contributions to the manuscript are presented in the subsequent table.

Authors	Author position	Scientific ideas (%)	Data generation (%)	Analysis and Interpretation (%)	Paper writing (%)
Patricia Malitzke	First	80	100	90	90
Constance Richter	Second	10	0	5	5
Stephan Schwan	Third	10	0	5	5
Title of the paper	Relationship between eye movement behavior and vocational interests				
Status in publication process	Published				

2.1 Study 1 – Manuscript 1

Relationship between eye movement behaviour and vocational interests

1 Introduction

The analysis of eye movements reveals more about our personality than we realise. The examination of personality traits with the help of eye movements is not widely used in research. The most common method to measure vocational interests are self-reports. This method is often criticised because it is prone to errors. Extreme responses or reading disabilities bias the results. An evaluation of interests using top-down guided visual attention can avoid these errors, because it is language independent and the eye movement cannot be controlled completely arbitrarily. Therefore, this paper aims to provide insights into the relationship between vocational interest and eye movement behavior as a new basis for career counseling. A complex image was used as a stimulus that depicts six different professions related to Holland's RIASEC model. The new approach of this study is that viewers have to choose between different vocational activities within one pictorial stimulus, based on their vocational interests.

1.1 Vocational interest

Much research has been done on vocational behavior (Savickas, 2021). This includes vocational interests, which are an important factor in career choices. Vocational interest define the extent to which people have preferences regarding occupational activities or career paths (Schermer, 2017). Several studies have explored which factors influence vocational choices. In addition to gender, school grades, parental socialisation and self-perception, interests are one of the most influential determinants of vocational choices (Valentine, 2023; Volodina & Nagy, 2016) In the literature on career choice certainty, there is a general agreement of no substantial changes of interests from the age of 16 (Nagy & Husemann, 2010). One of the most widely used models of vocational interest has been proposed by John L. Holland (1997). His career choice theory is firmly anchored in today's career counselling and in work psychology. Holland's model combines assumptions from previous theories, such as Person-Environment Matching and Life Space Theory (Holland, 1997). According to Holland's model, individuals' vocational interests and work environments are divided into six dimensions, also called the RIASEC types: Realistic, Investigative, Artistic, Social, Enterprising, and Conventional (see Table 1). All personality types deal with environmental challenges and tasks in various ways. They select and process information differently and have certain talents and abilities. The goal of the theory is to match the personality type with the corresponding work environment (Holland, 1997). There has been extensive research on the model's stability, validity and hexagonal structure with approximately 200 studies (Tarnai & Hartmann, 2016).

Table 1: Specification of Holland's RIASEC types (Bergmann & Eder, 2019)

Realistic	• Working with materials, tools and machines • Skills in technical, mechanical, electronical or agricultural fields
Investigative	• Preferring systematic, creative and scientific tasks • Working in physical, biological or cultural sectors
Artistic	• Favouring open, unstructured and creative activities • Working with materials, language and people in music, art, acting and writing
Social	• Preferring tasks like caring for, supporting or educating people • Attach importance to ethics, helpfulness and solidarity
Enterprising	• Masters in convincing, leading and manipulating • Pursuing organisational, economic or political goals
Conventional	• Favouring systematic handling of data, documents or materials • Working in computational, administrative or business areas

1.2 Measurement of vocational interests

Both cross-sectional studies, which provide an overview of vocational interest trends, and longitudinal studies, which analyze individual interest development over time, are available. Vocational interests are typically measured via self-report questionnaires, such as EXPLORIX® (Singer et al., 2007) or AIST-3 (General Interest Structure Test) (Bergmann & Eder, 2019), which are based on the RIASEC model. However, self-reports for vocational interests have some limitations. Participants may show systematic biases, responding either more extremely or moderately (Aichholzer, 2013); language dependence can cause comprehension issues for non-native speakers and individuals with dyslexia; and social influences may affect pupils' choices, leading them to report interests that do not reflect their true preferences. Additionally, lengthy questionnaires can decrease attention and motivation, resulting in inconclusive and non-representative responses. Thus, a quicker, more objective approach to measuring vocational interests is needed.

1.3 Interests and eye movement behavior

Eye movements are guided not only by bottom-up processes, such as stimulus design, but are also influenced by personality traits and mental states (Hoppe et al., 2018; Sarsam et al., 2023; Zhu et al., 2018). For example, curiosity can be predicted through visual search behavior and attention patterns (Berlyne, 1966; Collins et al., 2004). The number of image regions visited in a free-viewing task can be correlated with self-reported curiosity scores, indicating that increased curiosity resulted in visits to a greater number of regions (Risko et al., 2012). Additionally, personality traits are related to visual search performance. Conscientiousness, one of the Big Five personality traits, can affect visual search accuracy, specifically by enabling for example early-career and experienced professionals to quickly locate a target between distractors in a simple search task. Assessments of conscientiousness could be valuable in hiring processes for positions that require strong visual search skills (Biggs et al., 2017). Furthermore, pupil size, eye blinks, and saccadic movements can provide insights into individuals' emotional states. Positive emotions are associated with longer fixation durations and higher fixation counts (Alshehri & Alghowinem, 2013; Gere et al., 2017; Macatee et al., 2017).

There is limited research investigating the relationship between interest and eye movements, as most studies focus primarily on visual attention and ocular measurements (Humphreys & Bruce, 1990; Posner, 1980; Šola et al., 2022). In this study, interest is examined as an indicator of sustained attention to visual stimuli. Previous research has demonstrated that fixation patterns in both infants and adults can significantly predict situational interest in semantically informative objects. Longer fixation times indicate heightened interest in presented stimuli, such as faces and everyday objects (Henderson et al., 1999; Langsdorf et al., 1983). Fixation count can serve as a reliable indicator for regions of interest within pictures. Despite the presence of various visual distractors, a higher fixation count consistently signifies increased interest in specific image areas (Engelke & Le Callet, 2015). Interest is also linked to saccadic behavior. Novel and engaging stimuli such as images and microvideos can provoke longer saccades and indicate situational interest (Soleymani & Mortillaro, 2018). To date, no studies have looked at the relationship between ocular parameters and longer-lasting interest such as vocational interest.

1.4 Present research

This study examines which ocular metrics can predict vocational interest by testing parameters suggested in previous studies. To date, research mostly focussed on situational interest and simple stimuli (Engelke & Le Callet, 2015; Henderson et al., 1999). In comparison, the present research analyzed vocational interest as a long-term trait, using linear regression models at a within-person level. Therefore, three hypotheses were defined (see below). A complex image stimulus was created which represented six professions, categorized according to Holland's vocational model (Holland, 1997).

Dwell time, fixation count, and time to first fixation were collected across the six areas of interest (AOIs) within the image. The study employs a top-down, goal-oriented observation approach within a forced-choice task to encourage participants to make intuitive decisions regarding their career preferences. Additionally, this study evaluates, if self-reported image preferences can predict vocational interests, too. This design serves as a potential foundation for developing a perception-based vocational interest assessment tool.

Hypothesis H1: For each RIASEC type, there is a positive correlation between the strength of interest and the average fixation rate as well as the dwell time in a corresponding area of interest (AOI). Additionally, there is a negative correlation between the strength of interest and the time until first fixation of an AOI.

Hypothesis H2: For each RIASEC type, there is a positive correlation between the strength of interest and an occupation-related evaluation.

Hypothesis H3: For each RIASEC type, there is a positive correlation between an occupation-related evaluation and the average fixation rate as well as the dwell time in a corresponding AOI. Furthermore, there is a negative correlation between the occupation-related evaluation and the time until first fixation of an AOI.

2 Method

2.1 Participants

To determine the sample size of the preregistered study (AsPredicted number: #87630), an a priori power analysis was performed. A minimum sample of 85 participants was necessary to detect a medium effect ($f = 0.15$) with a sufficient power of 0.80 ($\alpha = 0.008$). Excluded from the study were participants outside the age range of

16 to 19, who exhibit ametropia, had not answered all the items of the verbal vocational interest tests, failed in eye tracking calibration and/or were not native German speakers. A solid knowledge of German was required for this study in order to complete the verbal vocational interest test (AIST-3). 110 pupils participated in the study. This number was corrected to 102. Eight data sets were removed for whom the calibration values ($x \leq 0.8$) of the eye tracker did not correspond to the target value or for whom the display of the stimulus was incorrect. The average age was 17.25 years ($SD = 0.969$). 43 of the participants were male, 58 of the participants were female, and one participant was diverse. Students from seven (specialised) secondary and high schools in the local area of Aalen and Zwickau participated in the study. All participants provided their informed consent and were aware that they could stop data recording at any time. An approval from the ethics committee of the University of Tübingen was obtained (LEK 2022/004).

2.2 Material

2.2.1 Pictorial stimulus

For the creation of the stimulus, a prestudy ($N = 26$) was carried out to rate different image styles, to collect presentation ideas and to select the most suitable artist. The stimulus was meant to be a complex image showing six professions. The following requirements had to be met: (1) clear identification of interactions and activities, (2) unambiguous display of people and objects, (3) uniformity in colors, shapes, brightness, and contrasts within the image, (4) presence of diversity (multicultural, not stereotyped by sex or age), and (5) avoidance of an overwhelming perception when viewing the image. An online survey was created and conducted on the QuestionPro online platform.

Additionally, the prestudy determined the typical professions associated with each RIASEC type. Participants were asked to imagine characteristics of the RIASEC types. With the help of a lexical analysis, keywords were defined. The following six professions resulted from the clustering of the participants' answers: painter (Artistic), carpenter (Realistic), nurse (Social), logistician (Conventional), scientist (Investigative), and entrepreneur (Enterprising).

The German artist Natalie Töppe created six variations of an illustrated image, featuring randomly selected positions for each profession (see Appendix A.1). The picture (see Figure 1) shows a house with six rooms (areas of interest)–one per profession. Interactions, work equipment, and room furnishings were adapted to the respective job.

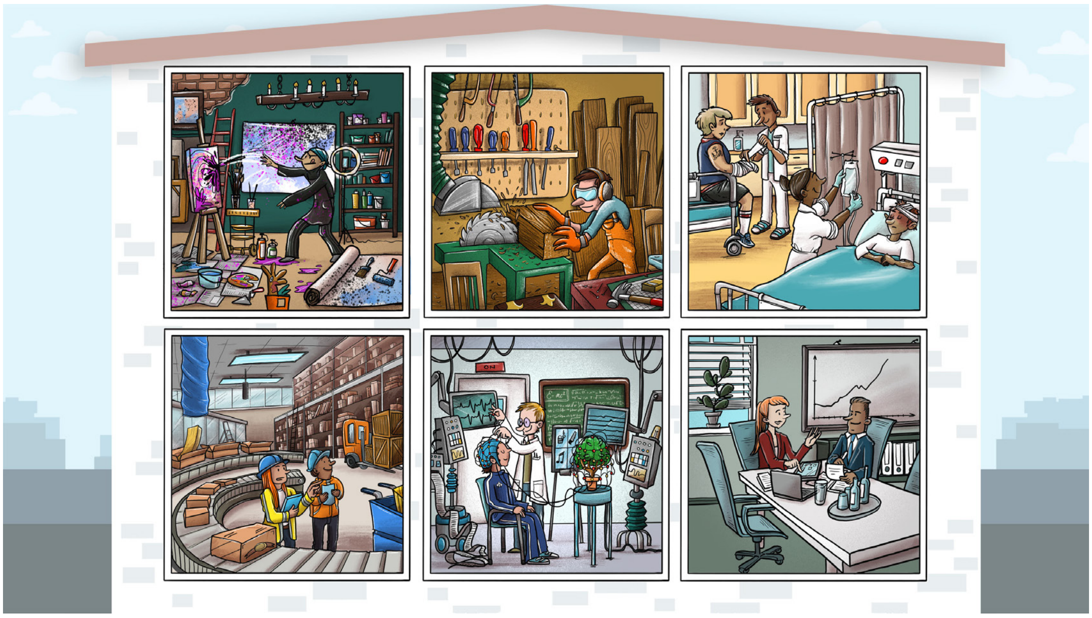


Figure 1: Variant of the eye tracking stimulus (clockwise from top left: Artistic, Realistic, Social, Enterprising, Investigative, Conventional); ©Aalen University

2.2.2 Standardised vocational interest test

The AIST-3 is founded on Holland's vocational interest theory, boasts a robust research background, and has been employed in career counseling. The AIST-3 consists of 60 items rated on a 5-point Likert scale. Following are six example items for each dimension: ‘working with machines and technical devices’ (Realistic), ‘carrying out experiments in a test laboratory' (Investigative), 'writing stories or reports' (Artistic), 'looking after or caring for other people' (Social), 'leading a team at work' (Enterprising), and 'keeping accounting records' (Conventional). The scores have a reported internal consistency between 0.86 and 0.90 and an one-month stability between 0.87 and 0.92 for each dimension (Bergmann & Eder, 2019). The scores of the present study revealed an internal consistency ranging from 0.84 to 0.90.

For the current study, the AIST-3 was selected for the following reasons: extensive research base (e.g., the norm values were determined on the basis of data collection with more than 4000 people), no dichotomous response format or forced-choice tasks, reply time within 15 minutes, analysis of intraindividual interests and a small number of interest categories. The collection of vocational interest data was carried out through the online Hogrefe Test System (HTS).

2.2.3 Occupation-related evaluation (query)

In response to the query, participants were tasked with rating each area of interest on a 7-point scale based on their level of interest in engaging in the portrayed vocational activity. The scale ranges from 1 = 'very much' to 7 = 'not at all'. The AOIs and scale ratings were shown one after the other. Every item asked the question: 'How interested are you in the professional activity of the image section shown? Rate your interest on the scale.'. Due to the presence of only one item for each RIASEC type, it is important to note that the internal consistency of the query could not be calculated retrospectively.

2.3 Eye tracking

Binocular gaze data were tracked using a state-of-the-art remote eye tracker from SensoMotoric Instruments (SMI) at 60 Hz. The eye tracker has a reported gaze estimation accuracy of 0.4 °. The stimulus was presented on a 15-inch Dell notebook screen with 1920 x 1080 px resolution. The task started with a calibration points-validation procedure with nine calibration and four validation points. Calibration was successful if the offset was less than 0.8 °. The six different scenes of the image representing the six RIASEC types were defined as areas of interest (AOIs) with a size of 416 x 416 px. Average fixation rate (average number of fixations per AOI), dwell time (sum of all fixations and saccades in one AOI), and time until first fixation (also called: entry time; the time it takes for participants' gaze to fixate one of the six AOIs) were measured. Based on the criteria according to Hooge et al., only monocular data from the left eye were used (Hooge et al., 2019).

2.4 Procedure

Participants were not informed in advance about the study's procedures or the nature of the data collection, a deliberate measure to prevent premature influence on their responses. Precautions were also taken to avoid different environmental conditions, such as the influence of light. It was ensured that the exposure was the same at all data-collecting locations. During data collection, one participant and one researcher sat next to each other at a table. Participants read the study description, provided a declaration of consent, acknowledged data privacy, and were assigned an ID number to guarantee anonymity. Data was collected on a laptop using AIST-3, eye tracker, and a query.

Initially, participants independently completed AIST-3. Subsequently, the researcher guided them through the eye tracking task, utilizing a chin and forehead rest for stability. Before the stimulus was presented for 30 seconds, participants were instructed with the task: 'Look at the following picture and decide: What professional activity would you like the most?'. Task formulations and stimulus duration were validated in a pretest, omitting the use of a fixation cross to grant participants the freedom to start exploring the picture where they desired. Following this, participants responded to the query. Finally, as an incentive, the researcher presented and elucidated the scan paths to the participants.

2.5 Data analysis

2.5.1 Eye tracking

To investigate the bottom-up influence of the stimulus, a salience map of the image was created with MATLAB using Itti and Koch's code (Itti et al., 1998). This was done to identify possible attention triggers through colours, shapes, contrasts, and object orientation. Compared to the participants scan paths and heatmaps, the results showed that design played a minor role. The participants' attention was drawn primarily by the search task, and not by bottom-up features.

Data from the eye tracking parameters dwell time, fixation count and time to first fixation was exported from the SMI BeGaze program. This data belongs to the category of reaction times and, does not follow a normal distribution. According to the suggestions of Lindeløv (2019) a cubic root transformation has been applied to all eye tracking parameters (Lindeløv, 2019), so that the residuals of the regression models were normally distributed.

2.5.2 AIST-3 and image query

Participants' responses in the AIST-3 were exported from the Hogrefe Test System (HTS). The raw scores for each RIASEC type were used in subsequent analyzes. The AIST-3 data showed a normal distribution and did not require transformation. However, the query data was different, as it did not follow a normal distribution. This was attributed to the small number of items and the non-normal distribution of preferences across the RIASEC dimensions. Therefore, an inverse transformation of the query data was performed to meet the assumptions of linear regression models.

2.5.3 Regression models

Simple and multilevel linear regression models were computed. The models were run using the R package lm4 of Bates et al. (2015) for each RIASEC type. An intercorrelation matrix revealed high co-linearity ($0.87 \leq r \leq 0.91$) between dwell time and fixation count. Therefore, the Akaike Information Criterion (AIC) for every model was checked with the R-function ‘screenreg’ (Leifeld, 2013) and consequently the models with lower AIC were chosen. Table 2 displays the different regression models according to the hypotheses.

Table 2: Overview hypotheses and regression models

	H1		H2		H3	
	Criterion	Predictor	Criterion	Predictor	Criterion	Predictor
Simple linear regression	AIST-3 data	Fixation count	AIST-3 data	Query data	Query data	Fixation count
Multilevel linear regression		Dwell time, Entry time	-			Dwell time, Entry time

The models of hypothesis H1 tested the associations between self-reported vocational interest in a standardized career test and eye movement behavior while viewing occupational images. The models of hypothesis H2 examined the relationship between self-reported vocational interest in the image query and self-reported vocational interest in the standardized test inventory. The models for hypothesis H3 explored the potential effects between self-reported interest in the image query and involuntary eye movements while viewing the stimulus. Data, image stimuli and code used in this study are available on OSF ([dataset] Malitzke, 2024) and can be freely accessed for further research.

3 Results

Based on the AIST-3 responses, the participants' score for each of the RIASEC types was calculated. No RIASEC codes (three profiles) were generated, as the correlations between the RIASEC types for each measurement were investigated. A descriptive analysis of the interest distribution across all variables is available in Appendix A.2. The following sections detail the results of the regression models.

3.1 Relationship eye movement/interest

This section introduces the results of hypothesis H1 for each RIASEC type. The independent variable is the AIST-3 data, and the predictors are dwell time, entry time and fixation count (see Table 3). Statistical significance ($p < 0.01$) is reached for dwell time ($0.44 \leq r \leq 0.52$) and fixation count ($0.35 \leq r \leq 0.43$) in all dimensions except for 'Conventional'. The entry time does not exhibit significant correlations. H1 can be accepted for dwell time and fixation count regarding the dimensions Realistic, Investigative, Artistic, Social, and Enterprising.

Table 3: Summary regression models of H1. Bold values represent significant correlations (**p < 0.01).

Predictor	*b*	*b* 95% CI	*beta*	*beta* 95% CI	*sr^2*	*sr^2* 95% CI	*r*	Fit
Criterion: AIST-3 Realistic								
(Intercept)	13.06**	[7.34, 18.78]						
Dwell Time Realistic	**0.92****	**[0.62, 1.23]**	**0.52**	**[0.35, 0.69]**	**0.27**	**[0.12, 0.42]**	**0.52****	R^2 = 0.274** 95% CI[0.13, 0.40]
Entry Time Realistic	-0.08	[-0.37, 0.21]	-0.05	[-0.22, 0.12]	0.00	[-0.01, 0.02]	-0.07	
(Intercept)	13.11**	[6.35, 19.87]						
Fixation Count Realistic	**6.26****	**[2.96, 9.55]**	**0.35**	**[0.17, 0.54]**	**0.12**	**[0.03, 0.25]**	**0.35****	R^2 = 0.124** 95% CI[0.03, 0.25]
Criterion: AIST-3 Investigative								
(Intercept)	14.99**	[8.40, 21.58]						
Dwell Time Investigative	**0.91****	**[0.58, 1.23]**	**0.49**	**[0.32, 0.67]**	**0.24**	**[0.09, 0.38]**	**0.49****	R^2 = 0.241** 95% CI[0.10, 0.36]
Entry Time Investigative	0.01	[-0.27, 0.29]	0.01	[-0.17, 0.18]	0.00	[-0.00, 0.00]	-0.06	
(Intercept)	14.13**	[7.26, 20.99]						
Fixation Count Investig.	**7.50****	**[4.36, 10.64]**	**0.43**	**[0.25, 0.61]**	**0.18**	**[0.06, 0.31]**	**0.43****	R^2 = 0.183** 95% CI[0.06, 0.31]
Criterion: AIST-3 Artistic								
(Intercept)	6.73	[-0.14, 13.60]						
Dwell Time Artistic	**1.12****	**[0.71, 1.52]**	**0.47**	**[0.30, 0.65]**	**0.22**	**[0.08, 0.36]**	**0.49****	R^2 = 0.249** 95% CI[0.11, 0.37]
Entry Time Artistic	0.22	[-0.11, 0.55]	0.11	[-0.06, 0.29]	0.01	[-0.03, 0.05]	0.16	
(Intercept)	9.59*	[1.09, 18.09]						
Fixation Count Artistic	**7.87****	**[3.77, 11.98]**	**0.36**	**[0.17, 0.54]**	**0.13**	**[0.03, 0.25]**	**0.36****	R^2 = 0.126** 95% CI[0.03, 0.25]
Criterion: AIST-3 Social								
(Intercept)	14.76**	[8.13, 21.39]						
Dwell Time Social	**0.86****	**[0.53, 1.19]**	**0.47**	**[0.29, 0.65]**	**0.21**	**[0.07, 0.35]**	**0.44****	R^2 = 0.217** 95% CI[0.08, 0.34]
Entry Time Social	0.24	[-0.05, 0.54]	0.15	[-0.03, 0.33]	0.02	[-0.03, 0.07]	0.06	
(Intercept)	15.42**	[8.00, 22.84]						
Fixation Count Social	**7.11****	**[3.78, 10.44]**	**0.39**	**[0.21, 0.57]**	**0.15**	**[0.04, 0.28]**	**0.39****	R^2 = 0.152** 95% CI[0.04, 0.28]
Criterion: AIST-3 Enterprising								
(Intercept)	22.33**	[16.76, 27.90]						
Dwell Time Enterprising	**0.70****	**[0.43, 0.97]**	**0.46**	**[0.28, 0.64]**	**0.21**	**[0.07, 0.35]**	**0.45****	R^2 = 0.212** 95% CI[0.08, 0.33]
Entry Time Enterprising	-0.13	[-0.41, 0.14]	-0.08	[-0.26, 0.09]	0.01	[-0.02, 0.04]	-0.04	
(Intercept)	20.06**	[13.73, 26.38]						
Fixation Count Enterpr.	**5.75****	**[3.08, 8.42]**	**0.39**	**[0.21, 0.58]**	**0.15**	**[0.05, 0.28]**	**0.39****	R^2 = 0.154** 95% CI[0.05, 0.28]
Criterion: AIST-3 Conventional								
(Intercept)	27.12**	[20.07, 34.17]						
Dwell Time Conventional	-0.07	[-0.52, 0.37]	-0.03	[-0.23, 0.17]	0.00	[-0.01, 0.01]	-0.03	R^2 = 0.002 95% CI[0.00, 0.02]
Entry Time Conventional	-0.03	[-0.29, 0.23]	-0.02	[-0.22, 0.18]	0.00	[-0.01, 0.01]	-0.02	
(Intercept)	24.95**	[18.49, 31.42]						
Fixation Count Convent.	0.44	[-2.97, 3.85]	0.03	[-0.17, 0.22]	0.00	[0.00, 0.04]	0.03	R^2 = 0.001 95% CI[0.00, 0.04]

3.2 Relationship image rating/interest

The analyzes of hypothesis H2 reveal similar results. The independent variable is the AIST-3 data, and the predictor is the query data (refer to Table 4). Significant correlations ($p < 0.01$) are found for Realistic, Investigative, Artistic, Social, and

Enterprising (0.39 ≤ r ≤ 0.52), while none are observed for Conventional. H2 is supported for the first five RIASEC types mentioned, while the hypothesis is rejected for the Conventional dimension. This underscores the positive association between vocational interests and an occupation-related image evaluation.

Table 4: Summary regression models of H2. Bold values represent significant correlations (**p < 0.01).

Predictor	*b*	*b* 95% CI	*beta*	*beta* 95% CI	sr^2	sr^2 95% CI	*r*	Fit
Criterion: AIST-3 Realistic								
(Intercept)	21.39**	[18.91, 23.87]						R^2 = 0.149** 95% CI[0.04, 0.28]
Query Realistic	**14.54****	**[7.66, 21.43]**	**0.39**	**[0.20, 0.57]**	**0.15**	**[0.04, 0.28]**	**0.39****	
Criterion: AIST-3 Investigative								
(Intercept)	24.59**	[22.35, 26.84]						R^2 = 0.266** 95% CI[0.13, 0.39]
Query Investigative	**17.08****	**[11.44, 22.72]**	**0.52**	**[0.35, 0.69]**	**0.27**	**[0.13, 0.39]**	**0.52****	
Criterion: AIST-3 Artistic								
(Intercept)	20.57**	[18.13, 23.01]						R^2 = 0.207** 95% CI[0.08, 0.34]
Query Artistic	**17.94****	**[10.97, 24.91]**	**0.45**	**[0.28, 0.63]**	**0.21**	**[0.08, 0.34]**	**0.45****	
Criterion: AIST-3 Social								
(Intercept)	25.53**	[23.04, 28.03]						R^2 = 0.213** 95% CI[0.09, 0.34]
Query Social	**16.36****	**[10.13, 22.60]**	**0.46**	**[0.29, 0.64]**	**0.21**	**[0.09, 0.34]**	**0.46****	
Criterion: AIST-3 Enterprising								
(Intercept)	26.79**	[24.25, 29.32]						R^2 = 0.257** 95% CI[0.12, 0.39]
Query Enterprising	**16.82****	**[11.15, 22.50]**	**0.51**	**[0.34, 0.68]**	**0.26**	**[0.12, 0.39]**	**0.51****	
Criterion: AIST-3 Conventional								
(Intercept)	25.16**	[22.54, 27.79]						R^2 = 0.003 95% CI[0.00, 0.06]
Query Conventional	2.36	[-6.65, 11.37]	0.05	[-0.15, 0.25]	0.00	[0.00, 0.06]	0.05	

3.3 Relationship image rating/eye movements

The results of hypothesis H3 are as follows. The independent variable is the query data, and the predictors are dwell time, entry time and fixation count (see Table 5). Statistical significance (p < 0.01) is reached for dwell time (0.50 ≤ r ≤ 0.64) and fixation count (0.42 ≤ r ≤ 0.55) in all dimensions except for 'Conventional'. There is no statistical significance for the predictor entry time in all dimensions. H3 can be accepted for dwell time and fixation count regarding the dimensions Realistic, Investigative, Artistic, Social, and Enterprising and rejected for Conventional.

Table 5: Summary regression models H3. Bold values represent significant correlations (**p < 0.01).

Predictor	*b*	*b* 95% CI	*beta*	*beta* 95% CI	sr^2	sr^2 95% CI	*r*	Fit
Criterion: Query Realistic								
(Intercept)	-0.09	[-0.24, 0.06]						R^2 = 0.283** 95% CI[0.13, 0.40]
Dwell Time Realistic	**0.03****	**[0.02, 0.03]**	**0.53**	**[0.36, 0.70]**	**0.28**	**[0.13, 0.43]**	**0.53****	
Entry Time Realistic	0.00	[-0.01, 0.01]	0.04	[-0.13, 0.21]	0.00	[-0.01, 0.02]	0.01	
(Intercept)	-0.14	[-0.31, 0.04]						R^2 = 0.206** 95% CI[0.08, 0.33]
Fixation Count Realistic	**0.21****	**[0.13, 0.30]**	**0.45**	**[0.28, 0.63]**	**0.21**	**[0.08, 0.33]**	**0.45****	
Criterion: Query Investigative								
(Intercept)	-0.09	[-0.28, 0.10]						R^2 = 0.314** 95% CI[0.16, 0.43]
Dwell Time Investigative	**0.03****	**[0.02, 0.04]**	**0.52**	**[0.36, 0.69]**	**0.27**	**[0.13, 0.42]**	**0.54****	
Entry Time Investigative	-0.01	[-0.01, 0.00]	-0.14	[-0.31, 0.03]	0.02	[-0.03, 0.06]	-0.21*	
(Intercept)	-0.14	[-0.35, 0.06]						R^2 = 0.174** 95% CI[0.06, 0.30]
Fixation Count Investig.	**0.22****	**[0.13, 0.32]**	**0.42**	**[0.24, 0.60]**	**0.17**	**[0.06, 0.30]**	**0.42****	
Criterion: Query Artistic								
(Intercept)	-0.19*	[-0.37, -0.02]						R^2 = 0.258** 95% CI[0.11, 0.38]
Dwell Time Artistic	**0.03****	**[0.02, 0.04]**	**0.50**	**[0.32, 0.67]**	**0.24**	**[0.10, 0.39]**	**0.50****	
Entry Time Artistic	0.00	[-0.00, 0.01]	0.07	[-0.10, 0.24]	0.00	[-0.02, 0.03]	0.12	
(Intercept)	-0.22*	[-0.43, -0.02]						R^2 = 0.196** 95% CI[0.07, 0.32]
Fixation Count Artistic	**0.25****	**[0.15, 0.35]**	**0.44**	**[0.27, 0.62]**	**0.20**	**[0.07, 0.32]**	**0.44****	
Criterion: Query Social								
(Intercept)	-0.23**	[-0.39, -0.07]						R^2 = 0.417** 95% CI[0.26, 0.53]
Dwell Time Social	**0.03****	**[0.03, 0.04]**	**0.65**	**[0.50, 0.81]**	**0.41**	**[0.27, 0.56]**	**0.64****	
Entry Time Social	0.00	[-0.00, 0.01]	0.05	[-0.10, 0.21]	0.00	[-0.01, 0.02]	-0.07	
(Intercept)	-0.28**	[-0.47, -0.09]						R^2 = 0.299** 95% CI[0.16, 0.42]
Fixation Count Social	**0.28****	**[0.20, 0.37]**	**0.55**	**[0.38, 0.71]**	**0.30**	**[0.16, 0.42]**	**0.55****	
Criterion: Query Enterprising								
(Intercept)	-0.03	[-0.18, 0.12]						R^2 = 0.343** 95% CI[0.19, 0.46]
Dwell Time Enterprising	**0.03****	**[0.02, 0.03]**	**0.59**	**[0.42, 0.75]**	**0.34**	**[0.19, 0.49]**	**0.58****	
Entry Time Enterprising	-0.01	[-0.01, 0.00]	-0.11	[-0.27, 0.05]	0.01	[-0.02, 0.05]	-0.06	
(Intercept)	-0.13	[-0.31, 0.04]						R^2 = 0.263** 95% CI[0.13, 0.39]
Fixation Count Enterpr.	**0.23****	**[0.15, 0.30]**	**0.51**	**[0.34, 0.68]**	**0.26**	**[0.13, 0.39]**	**0.51****	
Criterion: Query Conventional								
(Intercept)	0.18*	[0.03, 0.34]						R^2 = 0.009 95% CI[0.00, 0.06]
Dwell Time Conventional	0.00	[-0.01, 0.01]	0.08	[-0.12, 0.28]	0.01	[-0.02, 0.04]	0.07	
Entry Time Conventional	0.00	[-0.00, 0.01]	0.06	[-0.14, 0.26]	0.00	[-0.02, 0.03]	0.06	
(Intercept)	0.23**	[0.08, 0.37]						R^2 = 0.002 95% CI[0.00, 0.05]
Fixation Count Convent.	0.02	[-0.06, 0.09]	0.04	[-0.16, 0.24]	0.00	[0.00, 0.05]	0.04	

4 Discussion

The aim of this study was to investigate the relationship between eye movement behavior in relation to a complex picture and vocational interest. Eye tracking was intended to avoid dyslexia (Aravind et al., 2015), the tendency toward extreme responses (Aichholzer, 2013), and biases through insufficient attention or motivation and social desirability (Gordon, 1987). The overall conclusion drawn from the analysis indicates a correlation between vocational interest and dwell time as well as fixation count. The higher the dwell time and fixation count, the more interesting was the depicted profession. This results supports evidence from previous observations (Engelke & Le Callet, 2015; e.g. Henderson et al., 1999; Langsdorf et al., 1983). Furthermore, an image-based query showed significant correlations with vocational interests. These findings provide a basis for the development of a visual vocational interest test. Future studies should further explore this relationship, focusing on validity aspects such as reliability and predictive validity, which were not addressed in the present study.

Statistical significance for predicting vocational interest was reached for dwell time, fixation count and the image rating (for five out of six RISAEC dimensions). The positive correlations between eye tracking parameters and vocational interest are moderate to high ($r_{MDwellTime}$ = 0.47, $r_{MFixationCount}$ = 0.38). Whereas previous studies examined eye movement and personality traits for whole pictures (Risko et al., 2012) and single objects (Biggs et al., 2017), the results of this study go beyond this and prove that individual interest can be queried in eye movements within a complex image and a forced-choice task. Contrary to expectations, no correlations were found between entry time and vocational interest. This could be attributed to the randomized positions of the AOIs, allowing participants the freedom to decide where to commence their observations as no fixation cross was presented in advance. The randomization of AOI positions prevented direct comparisons, resulting in the absence of correlations between the variables.

In addition, picture ratings have been shown to be suitable for determining vocational interests. The query was correlated with eye tracking parameters ($r_{MDwellTime}$ = 0.56; $r_{MFixationCount}$ = 0.47) and the AIST-3 results (r_M = 0.39). The former finding is not surprising, since both eye movements and the query analyzed the visual perception of the stimulus. Thus, the query results reflect the eye movement behavior and the vocational interests. These results support the theoretical background from other image-based vocational interest test like the photo interest test (Jardiniano et al., 2023; Jungo & Toggweiler, 2019). However, there is a risk of bias due to extreme responses or missing IMCs because the image evaluation works with a scale query like the classic tests.

None of the hypotheses showed significant correlations for the Conventional type, possibly indicating lower overall interest in this category among participants (see Appendix A.2 – Interest distribution). However, unlike the AIST-3 results, neither eye-tracking data nor the query supported this outcome. It is possible that only a few participants identified with the logistician role, favoring other jobs within the Conventional sector. Additionally, the work environments of the Conventional and Enterprising types are quite similar, which may have led some Conventional-type participants to identify more with Enterprising. Moving forward, more precise visual representations of both categories are needed to improve accuracy in participant identification.

A limitation of this study is the unequal distribution of participants' interest fields. Most adolescents expressed interest in dimension Enterprising, while few preferred Conventional, which should be considered when interpreting results. Additionally, no reliability estimate was provided for the occupation-related evaluation, as each RIASEC dimension was assessed with only one item. Future research should verify reliability using a test-retest approach. This study correlated interest with perception using only the primary RIASEC dimension; however, vocational interests often span multiple dimensions, typically involving all six. To simplify analysis, only the primary dimension was used here. In terms of visual perception, bottom-up processes may have influenced the results, as design features like color, shape, contrast, and object position could have drawn participants' attention, introducing bias. Interpretation should also consider that each participant began viewing from a different starting point, as no fixation cross was used, allowing free observation. Finally, a possible priming effect could have occurred because participants completed the AIST-3 before the eye-tracking test. Future research should address this by reversing the order.

5 Conclusion

This study reveals a connection between vocational interest and both dwell time and fixation count. While previous research showed that viewing time for entire images depends on situational interest, this study goes further by demonstrating that vocational interest as a longer-lasting personality trait can guide eye movements within complex images in a forced-choice task. Additionally, an occupation-related evaluation can serve as a language-free method for assessing career preferences. Eye tracking may save time that can be redirected toward personalized guidance in career counseling. Future research should explore how this testing method can be standardized, validated, and implemented in career counseling.

EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

Mathematisch-Naturwissenschaftliche Fakultät

Declaration according to § 5 Abs. 2 No. 8

of the PhD regulations of the Faculty of Science

-Collaborative Publications-

The following chapter (Chapter 2.2) consists of a manuscript that was co-authored by Stephan Schwan and Constance Richter.

The manuscript 'Beyond Self-Reports: Leveraging Visual Perception and Eye Tracking to Determine Vocational Interest' is already published in the journal 'Acta Psychologica' of Elsevier (doi: 10.1016/j.actpsy.2025.105359).

The proportional contributions to the manuscript are presented in the subsequent table.

Authors	Author position	Scientific ideas (%)	Data generation (%)	Analysis and Interpretation (%)	Paper writing (%)
Patricia Malitzke	First	80	100	90	90
Stephan Schwan	Second	10	0	5	5
Constance Richter	Third	10	0	5	5
Title of the paper	Beyond Self-Reports: Leveraging Visual Perception and Eye Tracking to Determine Vocational Interest				
Status in publication process	Published				

2.2 Study 2 – Manuscript 2

Beyond Self-Reports: Leveraging Visual Perception and Eye Tracking to Determine Vocational Interest

1 Introduction

Choosing a career is a decision in our lives that significantly shapes us. This study will demonstrate that the decision-making process affects us not only on a cognitive and emotional level, but also on a perceptual one. Eye movements are an expression of higher cognitive processes and are only partly under voluntary control. Our research shows that eye movements are suited to uncover inner convictions and choice certainty according to vocational interests. The aim of this study is to evaluate the predictive validity of eye movement metrics and to refine a testing protocol for effective application in practical career counselling settings.

1.1 Interest and perception

Interest can be a short-term state or a longer-lasting trait (Hidi et al., 2004). Regardless of the form, interest is strongly bound to higher cognitive processes (Ackerman, 1996; Ainley, 2006). Since interest implies an attentional focus on a certain topic or object it makes sense to assume that interest and perception are closely related to each other. Empirical evidence confirms this notion. The existing literature emphasises that total fixation time is a significant predictor of situational interest (Langsdorf et al., 1983), and viewing time correlates with self-reported interest (Evans & Day, 1971). Situational interest can be linked to eye movements when viewing miscellaneous stimuli such as random polygons, visual art, and poetry (Silvia, 2005). Apart from this, curiosity (in the form of attentional interest to novel stimuli) plays a major role in eye movement behaviour in naturalistic scene viewing. Thereby, the number of regions visited is an indicator for individual differences in perceptual curiosity (Risko et al., 2012). Thus, there is evidence for the relationship between situational and individual interest and eye movement behaviour.

In addition, fixation behaviour and saccadic behaviour are influenced by the (un)certainty of decision-making processes (Glaholt & Reingold, 2011; Horstmann et al., 2009; Wedel et al., 2023). Uncertainty in decision making increases the working memory load, which in turn leads to a greater number of fixations and longer saccades (Orquin & Mueller Loose, 2013). Brunyé and Gardony (2017) proceeded even further and found that several oculomotor parameters such as fixation duration and frequency, saccade amplitude or pupil diameter are influenced by decision certainty.

1.2 Vocational interest

Vocational interests are individual preferences for career paths and occupational activities (Schermer, 2017). They are a dispositional interindividual difference between humans (Rounds & Su, 2014). John L. Holland (1997) designed the most widely used model of vocational interests. His internationally recognised theory of career choice is part of current career counselling, work psychology, and organisational psychology. A central aspect of the model is the matching of person and environment. Therefore, individuals' interests and occupational environments are categorised into six RIASEC dimensions: **R**ealistic, **I**nvestigative, **A**rtistic, **S**ocial, **E**nterprising, and **C**onventional. The aim is to achieve an optimum equivalence of vocational interests and the corresponding work environments. The RIASEC types are characteristic personality traits and define different attitudes, behaviours, skills, information processing procedures, and coping styles of the individuals (Holland, 1997). Due to these cognitive distinctions, the model is ideally suited as a foundation for a perception-based analysis of individual interest.

In order to measure vocational interest, a variety of test methods are available. The tests possess good statistical characteristics regarding factor structure, internal consistency, and validity but also have some limitations. In Germany, there are two widespread test inventories, which are based on Holland's RIASEC model: the EXPLORIX® (Jörin Fux et al., 2004) and the Allgemeiner-Interessen-Struktur-Test AIST-3 (General Interest-Structure-Test) (Bergmann & Eder, 2019). These questionnaires can contain up to 60 items, leading to the first issue: attentional-based biases. Participants must maintain concentration and focus for at least 15 minutes while answering the questions. Another source of bias comes from the rating scales used in these standardised tests, where responses may be skewed by social desirability or acquiescent tendencies. Such biases can compromise the validity and reliability of the assessments (Gordon, 1987; Kreitchmann et al., 2019; van Herk et al., 2004). Additionally, questionnaires pose challenges due to their reliance on language. Individuals with reading difficulties, mental disabilities, or those who are non-native speakers often struggle with comprehension (Jardiniano et al., 2023). To minimise or eliminate these biases, a new approach for assessing vocational interests is needed.

Career counsellors already have several tools to identify career interests–including image-based questionnaires. There are inventories that use drawings as visual stimuli like 'The Geist Picture Interest Inventory GPII-R' (Geist, 1964) or the 'Reading-Free Vocational Interest Inventory R-FVII-R' (Becker, 1981). The 'Foto-Interessen-Test F-I-T' (Photo-Interest-Test) (Jungo & Toggweiler, 2019) and the 'Nonverbal Vocational Interest Scale NVIS' (Weißmann et al., 2022) rely on photographs. Furthermore, there are tests with reduced stimuli, such as pictograms (Boerchi & Magnano, 2015). They represent neither gender nor emotional moods. Despite their differences, all of these methods depend on the participants' conscious evaluation of stimuli and they partially use scale ratings. The aim of the current study is the analysis of the relationship between eye movements and vocational interest to set the theoretical basis for a text- and scale-free career test that can uncover hidden interests through involuntary behavioural reactions.

In questionnaire-based research, response time has been studied as an important decision-making parameter. Incorporating response time as a measured value has been shown to improve the accuracy of personality assessments (Guo et al., 2024). It also provides insight into the effort and motivation of participants when completing digital tests (Wise & Kong, 2005). Additionally, response time is often used in non-cognitive tests as a key metric (Kim & Bolt, 2023). In our study, we used response time as an indicator of choice certainty for vocational interest, in correlation with saccadic behaviour.

1.3 Previous study

In a previous study carried out by Malitzke et al. (2025a), the correlative relationship between eye movement behaviour and vocational interest was analysed. The purpose of the previous study was to analyse potential eye tracking parameters for the assessment of vocational interests. The stimulus was an illustrated image that showed six different occupations according to the RIASEC types. Each profession was defined as an area of interest (AOI). An eye tracker recorded time to first fixation, dwell time, and fixation count for each AOI. The results revealed notable correlations between verbal-tested vocational interest (via AIST-3) and fixation count ($r = 0.38$) as well as dwell time ($r = 0.47$) for five out of six RIASEC dimensions. Conventional was the only dimension which did not exhibit any significant correlations. Furthermore, the results indicated that an image rating (rating of the AOIs) could also be suitable to test vocational interest (r = 0.39). While the previous study demonstrated an association between vocational interests and eye movement behaviour, the predictive utility of eye tracking metrics for assessing vocational interests remains inconclusive. Notably, in the earlier study, eye tracking data were collected after participants had completed the standardised vocational interest inventory AIST-3. It is plausible that reflecting on their personal interests during the test may have influenced their gaze behaviour when viewing the stimuli, thereby reducing the spontaneity and intuitive nature of their eye movements. To address this limitation, the current study reversed the procedure: participants were first exposed to occupational images, followed by completion of the AIST-3. Nonetheless, several methodological challenges must still be resolved to establish a valid and standardised visual assessment tool for vocational interests. The present study aims to contribute to this goal by focusing on key aspects such as optimisation of the testing procedure, assessment of the reliability of eye tracking variables, and evaluation of predictive validity. This study represents a subsequent developmental phase in the refinement of an eye movement–based assessment of vocational interests.

1.4 Present research

In this preregistered study (AsPredicted number: #115385), participants were asked to choose their preferred career path through three methods: a visual exploration of occupational images, an image rating of AOIs and the assessment of vocational interests with a standardised questionnaire (AIST-3). An eye tracker recorded the eye movements and analysed the gaze behaviour while observing the complex image stimuli. With the help of simple and multilevel linear regressions, significant effects between vocational interest and eye movements were tested. In addition, it was analysed whether there is a significant correlation between participants' career choice certainty and saccadic behaviour.

In the present study, four hypotheses were defined to investigate the relationship between vocational interest and eye movement behaviour. The hypotheses are grounded in previous empirical findings by Engelke and Le Callet (2015), Silvia (2005), and Risko et al. (2012), all of whom reported correlations between situational interest and eye tracking parameters such as fixation count, fixation duration, and the number of perceived AOIs. In contrast, the current study focuses on a more enduring form of interest, vocational interest, which has received comparatively little attention in eye tracking research but may offer valuable implications for career counselling applications. Hypotheses H1 and H3 specifically addresses the association between self-reported vocational interest and eye movement metrics. Hypothesis H2 examines the extent to which occupational evaluations of visual stimuli align with self-reported vocational interests. Additionally, Hypothesis H4 explores the relationship between saccadic eye movements and career choice certainty. This approach is informed by findings from Brunyé and Gardony (2017) and Orquin and Mueller Loose (2013), who demonstrated that decision certainty can be inferred from saccadic patterns. The current study adopts a similar methodology, utilising response time as an indirect measure of career choice certainty.

Hypothesis H1: For each of the six RIASEC types, there is a positive correlation between the strength of vocational interest (measured via AIST-3) and eye movement behaviour (average fixation rate and dwell time) in the corresponding AOI. In addition, for each of the six RIASEC types, there is a negative correlation between the strength of vocational interest and the time until first fixation of an AOI.

Hypothesis H2: For each of the six RIASEC types, there is a positive correlation between the strength of vocational interest and the occupation-related evaluation of the corresponding AOI.

Hypothesis H3: For each of the six RIASEC types, there is a positive correlation between the eye movement behaviour (average fixation rate and dwell time) in the corresponding AOI and its occupation-related evaluation. In addition, for each of the six RIASEC types, there is a negative correlation between the time until first fixation of an AOI and its occupation-related evaluation.

Hypothesis H4: There is a negative correlation between the saccadic behaviour (saccade count and saccade duration) and the career choice certainty (response time in AIST-3).

2 Method

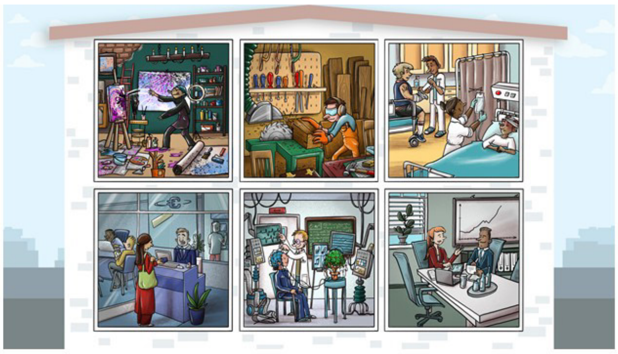
2.1 Participants

An a priori power analysis defined the sample size of this study. At least 47 participants were necessary to obtain a medium effect ($f = 0.29$) and a power of 0.95 ($\alpha = 0.05$). In the end 74 adolescents participated in the study, but only 67 data sets were included in the statistical analysis (male: 18; female: 49). The seven data sets were excluded because of an insufficient calibration value of the eye tracker. The average age was 16.66 years ($SD = 0.808$). The primary inclusion criteria for the participants were: (1) being between 16 and 19 years of age, (2) having native German language skills, (3) no visual impairment, (4) successfully completing the eye tracking calibration, and (5) answering all items on the verbal tests (image query and AIST-3). Adolescents from seven secondary and high schools in Germany, as well as adolescents visiting one of five career fairs in the local area of Aalen/Germany, attended the study. All participants provided written informed consent. An ethical approval was obtained from the ethics committee of the University of Tübingen (LEK 2022/004).

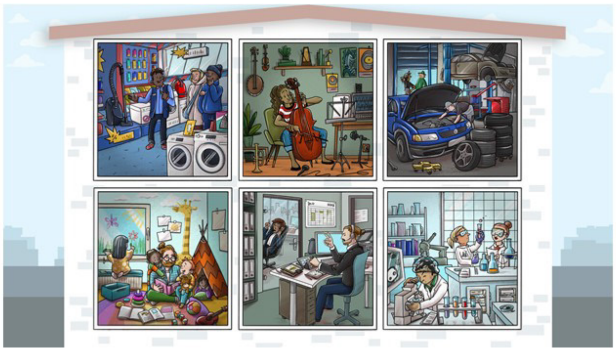
2.2 Materials

2.2.1 Pictorial stimuli

Two complex images were used as stimuli (see Figure 1). Each of them represents six professions according to Holland's RIASEC types. This was done to reduce the complexity of the career options (Nurcahyo et al., 2019) and to encourage participants to make quick and intuitive decisions. It was made sure that professions were chosen which matched different school-leaving qualifications. Stimulus 1 shows a painter (Artistic), a carpenter (Realistic), nurses and doctors (Social), a bank employee (Conventional), a cognitive researcher (Investigative) and entrepreneurs (Enterprising). In contrast to the stimulus of Malitzke et al. (2025a), a new occupation for the dimension Conventional was chosen. In the initial study, there were no significant correlations between eye movements and vocational interest of the Conventional dimension (Malitzke et al., 2025a). In order to improve the comprehensibility and attractiveness of the Conventional AOI, bank employees were depicted instead of logisticians. As there are numerous occupations that can be assigned to the six RIASEC types, a second image was created. This approach provided participants with a broader selection of potentially interesting professions. The increased number of AOIs was deliberately implemented to assess how the quality of eye tracking data evolves under more realistic testing conditions. In standardised assessments, various professions are evaluated; this capability should likewise be supported in the context of the eye tracking evaluation. Stimulus 2 displays a salesperson (Enterprising), a musician (Artistic), a mechanic (Realistic), a kindergarden teacher (Social), office administrators (Conventional) and laboratory assistants (Investigative). The working environment, interactions, colours, picture style, and number of people depicted were adapted to the respective profession. Illustrated stimuli instead of photographs were chosen to use stylised representations of the professions. This type of presentation is well suited to motivate young people in the career orientation phase because of the gamified approach. In addition, stylised depictions are more likely to help viewers identify with the characters depicted. The characters are not stereotyped by sex or age. They are multicultural, diverse, and representative. The positions of the professions (AOIs) were randomised. This resulted in six variants of each stimulus (see Appendix A.1 and A.2). Every participant got to observe one of the six variants of each stimulus at random.



Variant of the stimulus 1
clockwise from top left: Artistic, Realistic, Social, Enterprising, Investigative, Conventional
©Aalen University



Variant of the stimulus 2
clockwise from top left: Enterprising, Artistic, Realistic, Investigative, Conventional, Social
©Aalen University

Figure 1: Example variants of the eye tracking stimuli

2.2.2 Eye tracking

A high-quality remote eye tracker (60 Hz) from SMI (SensoMotoric Instruments) collected monocular eye movement data. It provides a sampling rate of 60 Hz and a gaze estimation accuracy of 0.4°. For the presentation of the stimuli, a 15-inch Dell notebook screen with a resolution of 1920 x 1080 px was used. The AOIs picturing the RIASEC types had a size of 416 x 416 px. In the test procedure, a calibration point validation with nine calibration points and four validation points was first performed. To obtain the best possible data quality, the offset must not be greater than 0.8 °. For each AOI, the following parameters were collected: (1) average fixation rate (average number of fixations per AOI), (2) dwell time (sum of all fixations and saccades in one AOI), and (3) time until first fixation (also called: entry time; the time it takes for participants' gaze to fixate one of the six AOIs). The saccade duration and saccade count were recorded for the entire image across all AOIs.

2.2.3 Occupation-related evaluation of the stimuli

The occupation-related evaluation (hereinafter referred to as image query) was chosen to allow deeper insights into the visual perception of the occupational presentations and into image-based self-reported vocational interest. This study validated established methods of vocational interest measurement with the new approach of eye tracking. For this reason, an image-based query was conducted. In the field of career counselling, image-based assessment methods are already employed to evaluate vocational interests (see Section 1.2). The present study adopted a similar visual assessment approach, utilising picture-based ratings to analyse participants' vocational interests. To validate the eye tracking data with the perception-based measure, participants' gaze patterns were correlated with their responses in the image query. Participants rated each AOI individually on a 5-point Likert scale according to their interest in the depicted vocational activity. Each item prompted the question: 'How interested are you in the occupational activity shown? Rate your extent of interest on the corresponding scale.'. Responses ranged from 1 ('not at all') to 5 ('very much'). This resulted in twelve scores–two per RIASEC type–which were later correlated with the eye tracking data. The procedure mirrors established practices in existing inventories such as the Swiss *F-I-T (Foto-Interessen-Test)* of Jungo and Toggweiler (2019).

2.2.4 Vocational interest test–AIST-3

A standardised and established vocational interest test (AIST-3) was used to validate the eye tracking results. The basis for this questionnaire is Holland's RIASEC model. The test has a broad research background and is widely used in career counselling. The inventory includes 60 items rated on a 5-point Likert scale (Bergmann & Eder, 2019). The scale ranged from 1 = 'not at all' to 5 = 'very much'. Examples for items are: 'install new parts in a computer' (Realistic), 'read a scientific article' (Investigative), 'design things beautifully' (Artistic), 'teach or educate someone' (Social), 'run a company or business' (Enterprising), and 'create and analyse statistics' (Conventional) (Bergmann & Eder, 2019). To determine the strength of vocational interest, raw values per RIASEC type were exported. To determine the career choice certainty, the response time of the items was utilised. The AIST-3 was chosen for several reasons: its extensive research foundation, the ability to complete it within 15 minutes, its analysis of intraindividual interests, and its grounding in Holland's RIASEC model. The data collection was carried out through the online platform Hogrefe Test System (HTS).

2.3 Procedure

To avoid any possible priming effect before data collection, the participants were unaware of the aim of the study. External factors, such as the incidence of light on the eye tracker and in the participants' eyes, were taken into account to ensure that all adolescents took part under similar environmental conditions. The participants sat centred on the laptop and the test leader next to them. First, the test leader explained the study procedure to the participants. Afterwards, the subjects provided a declaration of consent and acknowledged the privacy of their data. Each person received an anonymous identification number (ID). The participants were aware that they could cancel the test at any time. All eye tracking data, AIST-3 data, and image query data were recorded on the same laptop.

Initially, participants completed the automated eye tracking task. A chin and forehead rest was used for head stability. Participants were tasked with the question: 'Look at the following image and make a decision: What occupational activity do you prefer the most?'. Subsequently, the two stimuli were displayed for 30 seconds each. Fixation crosses ensured that all participants started their visual search from the same starting point in the middle of the picture. Subsequently, the participants answered the image query. Finally, participants rated their vocational interest in the AIST-3. As a thank you for their participation, the test leader showed the scan paths to the participants and gave career path suggestions for later career counselling.

2.4 Data analysis

2.4.1 Eye Tracking

The present study focusses on the top-down control of visual perception. So, the influence of bottom-up control had to be mitigated. To identify potential biases in the image design, salience maps were created in MATLAB using the algorithm of Itti and Koch (Itti et al., 1998). A comparison of the saliency maps with participants' scan paths revealed that features such as colour, contrast, shape, object orientation, and brightness had a minor role in stimuli perception; instead, the search task predominantly guided participants' eye movements. Moreover, the internal consistency was determined for dwell time and fixation count on stimulus 1 and 2. It ranged from |0.08| (Conventional) to 0.70 (Realistic) for dwell time and from 0.14 (Social) to 0.72 (Investigative) for fixation count.

Eye tracking data is a category of reaction time. Therefore, the eye tracking values and the residuals of the regression models were not normally distributed. Normally distributed residuals are a prerequisite for the regression analysis. To approximate a normal distribution, a cubic root transformation was applied to dwell time, fixation count, entry time, saccade count and saccade duration (Lindeløv, 2019). The intercorrelation matrices showed high collinearity ($0.78 \leq r \leq 0.94$) between dwell time and fixation count. Consequently, simple regression models and multilevel regression models were tested according to the Akaike Information Criterion (AIC) with the R function 'screen-reg' (Leifeld, 2013). The models with the lower AIC were chosen: a multilevel regression for dwell time and entry time as dependent variables and AIST-3 scores respectively image query data as criterion. For fixation count as dependent variable, a simple regression model was preferred with AIST-3 scores respectively image query data as criterion (see Table 1).

2.4.2 Image query

The data of the image query was collected with a digital survey right after the eye tracking task. The image query resulted in two rating scores per RIASEC dimension per participant. The two scores were cumulated to get one score for each RIASEC type. The internal consistency of the scores ranged from 0.21 (Enterprising) to 0.88 (Investigative). Overall, the image query data did not follow a normal distribution and required a transformation. This deviation was likely due to the limited number of items as well as an uneven distribution of participants' RIASEC preferences. Consequently, an inverse transformation was applied to the query data to obtain a better normal distribution of the residuals of the regression models.

2.4.3 AIST-3 questionnaire

Participants' AIST-3 answers and the response time for each item were collected with the Hogrefe Test System (HTS). For each RIASEC type, raw values were calculated. No RIASEC codes (three-letter-profiles) were created. Only one RIASEC dimension was used for the analysis of the correlations. This was done to reduce the complexity of the possible RIASEC variants. The AIST-3 scores of the present study revealed an internal consistency ranging from 0.87 to 0.92. The data displayed a normal distribution and did not require transformation. The response time for each item was combined to a cumulative response time per participant across all RIASEC dimensions. Just like the eye movement data, the response time data belongs to the category of reaction time. Consequently, the response time data was cubic root transformed to gain an approximately normal distribution of the regression residuals.

2.4.4 Regression models

This study used simple and multilevel linear regression models to test the hypotheses. For each RIASEC type, a model was run using the R package *lm4* developed by Bates et al. (2015). Table 1 explains the regression models according to the hypotheses. The models for hypothesis H1 analysed the relationship between self-reported vocational interest in the standardised career test AIST-3 and the eye tracking metrics (dwell time [ms], entry time [ms] and fixation count). The models for hypothesis H2 tested the correlations between self-reported vocational interest in the image query and self-reported interest in the AIST-3. The models for hypothesis H3 examined the association between the self-reported vocational interest in the image query and the eye tracking parameters (dwell time [ms], entry time [ms] and fixation count). The multilevel model for hypothesis H4 examined the relationship between the AIST-3 response time [s] and the saccadic behaviour (average saccade duration [ms] and saccade count). The data from stimulus 1 and stimulus 2 were combined. To test the prognostic validity of the models, a 10-fold cross validation was carried out for the models of hypothesis H1 and hypothesis H3. The data was randomly partitioned into ten equal-sized folds. In each iteration, nine folds were used for training and one for validation. This process was repeated so that each fold served as the validation set once. All cross validation analyses were performed using the R package *caret* developed by Kuhn (2008). Data, code and image stimuli used in the present study are available on the Center for Open Science repository OSF (https://osf.io/928we/) and can be freely accessed for further research.

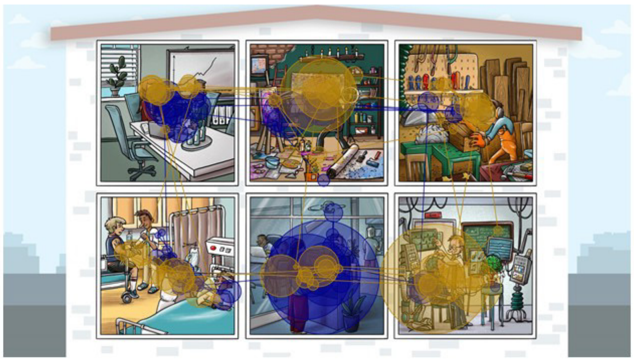
Table 1: Overview hypotheses and regression models

<table>
<tr><th rowspan="2"></th><th colspan="2">H1</th><th colspan="2">H2</th><th colspan="2">H3</th><th colspan="2">H4</th></tr>
<tr><th>Criterion</th><th>Predictor</th><th>Criterion</th><th>Predictor</th><th>Criterion</th><th>Predictor</th><th>Criterion</th><th>Predictor</th></tr>
<tr><td>Simple linear regression</td><td rowspan="2">AIST-3 data</td><td>Fixation count</td><td>AIST-3 data</td><td>Image query data</td><td rowspan="2">Image query data</td><td>Fixation count</td><td colspan="2">-</td></tr>
<tr><td>Multilevel linear regression</td><td>Dwell time, Entry time</td><td colspan="2">-</td><td>Dwell time, Entry time</td><td>Response time</td><td>Saccade duration, Saccade count</td></tr>
</table>

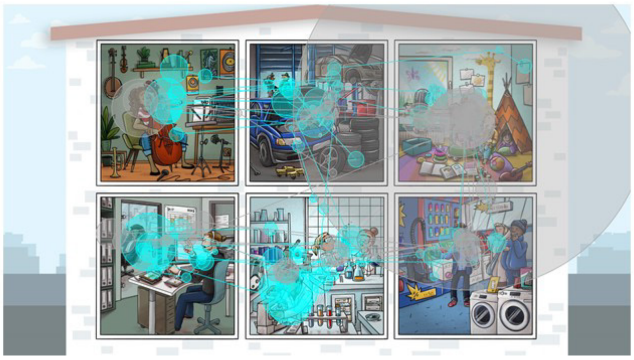
3 Results

This study employed quantitative techniques to analyse the relationship between eye movements and vocational interest, with a particular focus on top-down processing. An analysis of the interest distribution indicates that the participants' interests were not evenly distributed (see Appendix A.3). Based on the perceptual metrics (dwell time, fixation count, and image query), the majority of participants showed the greatest interest in the Investigative dimension, while the Realistic dimension received the least interest. However, the AIST-3 results revealed that the most engaging dimension was Enterprising, with Realistic again being the least interesting. These differences should be considered when interpreting the following results of the regression models.

Figure 2 illustrates the scan paths of four individual participants, each exhibiting a predominant interest in one or more dimensions of the RIASEC model. The scan paths were not subjected to qualitative analysis. Nevertheless, participants were shown their respective scan paths as an incentive. The test leader provided an explanation of the RIASEC framework alongside an interpretation of the observed gaze patterns. Subsequently, the participants engaged in career counselling sessions facilitated by the German Federal Employment Agency (Agentur für Arbeit).



Scan path examples for stimulus 1
The colours represent two different participants. Both participants were particularly interested in two dimensions (blue – Conventional and Enterprising; ochre – Investigative and Artistic).



Scan path examples for stimulus 2
The colours represent two different participants. The participant with the grey scan path prefers the Social dimension. The participant with the cyan scan path is interested in various dimensions (Artistic, Realistic, Conventional and Investigative).

Figure 2: Scan path examples for stimuli 1 and stimuli 2

3.1 Relationship between eye movement and interest

Firstly, the results of hypothesis H1 are reported for each RIASEC type. The criterion variable is the data of the AIST-3, and the predictors are dwell time, fixation count, and entry time (see Table 2). Statistical significance ($p < 0.01$) is reached in all RIASEC types for the predictor dwell time and in five out of six RIASEC dimensions for the predictor fixation count. The regression models identified positive correlations between $0.31 \leq r \leq 0.65$ for dwell time and $0.29 \leq r \leq 0.60$ for fixation count. For dwell time, Investigative exhibits the highest correlation and Conventional the lowest. For fixation count, Investigative shows the highest correlation and Enterprising the lowest. There is no significant correlation between fixation count and AIST-3 scores for dimension Conventional. Furthermore, no significant effects are found between entry time and AIST-3 data for all RIASEC types. For each regression model corresponding to a RIASEC dimension, a 10-fold cross-validation procedure was employed. In models utilising dwell time and entry time as predictors, the mean R^2 ranged from 0.24 (SD = 0.19) to 0.51 (SD = 0.23), with the highest performance observed for Investigative and the lowest for Enterprising. Similarly, models incorporating fixation count as the predictor yielded mean R^2 values ranging from 0.19 (SD = 0.21) to 0.47 (SD = 0.23), again with the Investigative dimension resulting in the highest value and the Enterprising dimension in the lowest. In summary, hypothesis H1 is accepted for dwell time in all dimensions and for fixation count in five out of six dimensions. Hypothesis H1 is rejected for entry time.

Table 2: Summary regression models of H1. Bold values represent significant correlations (* p < 0.05; ** p < 0.01)

Predictor	*b*	*b* 95% CI	*beta*	*beta* 95% CI	*sr²*	*sr²* 95% CI	*r*	Fit
Criterion: AIST-3 Realistic								
(Intercept)	14.80**	[3.75, 25.86]						R^2 = 0.203** 95% CI[0.04, 0.35]
Dwell Time Realistic	**0.96****	**[0.42, 1.50]**	**0.40**	**[0.18, 0.63]**	**0.16**	**[0.00, 0.32]**	**0.42****	
Entry Time Realistic	-0.40	[-0.99, 0.20]	-0.15	[-0.38, 0.08]	0.02	[-0.04, 0.08]	-0.21	
(Intercept)	8.13	[-1.15, 17.42]						R^2 = 0.149** 95% CI[0.03, 0.30]
Fixation Count Realistic	**7.98****	**[3.27, 12.70]**	**0.39**	**[0.16, 0.62]**	**0.15**	**[0.03, 0.30]**	**0.39****	
Criterion: AIST-3 Investigative								
(Intercept)	4.42	[-5.45, 14.30]						R^2 = 0.429** 95% CI[0.23, 0.56]
Dwell Time Investigative	**1.42****	**[1.00, 1.83]**	**0.65**	**[0.46, 0.84]**	**0.42**	**[0.24, 0.60]**	**0.65****	
Entry Time Investigative	0.06	[-0.55, 0.68]	0.02	[-0.17, 0.21]	0.00	[-0.01, 0.01]	0.11	
(Intercept)	2.29	[-6.71, 11.29]						R^2 = 0.358** 95% CI[0.18, 0.50]
Fixation Count Invest.	**12.04****	**[8.05, 16.03]**	**0.60**	**[0.40, 0.80]**	**0.36**	**[0.18, 0.50]**	**0.60****	
Criterion: AIST-3 Artistic								
(Intercept)	16.80**	[5.78, 27.81]						R^2 = 0.300** 95% CI[0.11, 0.44]
Dwell Time Artistic	**1.15****	**[0.68, 1.63]**	**0.51**	**[0.30, 0.71]**	**0.26**	**[0.08, 0.43]**	**0.51****	
Entry Time Artistic	-0.58	[-1.21, 0.04]	-0.20	[-0.41, 0.01]	0.04	[-0.04, 0.12]	-0.21	
(Intercept)	8.04	[-1.60, 17.69]						R^2 = 0.202** 95% CI[0.05, 0.36]
Fixation Count Artistic	**9.21****	**[4.68, 13.75]**	**0.45**	**[0.23, 0.67]**	**0.20**	**[0.05, 0.36]**	**0.45****	
Criterion: AIST-3 Social								
(Intercept)	12.07*	[2.15, 22.00]						R^2 = 0.218** 95% CI[0.05, 0.36]
Dwell Time Social	**0.94****	**[0.47, 1.40]**	**0.44**	**[0.22, 0.66]**	**0.20**	**[0.03, 0.36]**	**0.45****	
Entry Time Social	0.34	[-0.21, 0.88]	0.14	[-0.08, 0.36]	0.02	[-0.04, 0.08]	0.15	
(Intercept)	13.26*	[2.99, 23.53]						R^2 = 0.160** 95% CI[0.03, 0.32]
Fixation Count Social	**8.42****	**[3.64, 13.20]**	**0.40**	**[0.17, 0.63]**	**0.16**	**[0.03, 0.32]**	**0.40****	
Criterion: AIST-3 Enterprising								
(Intercept)	15.48**	[4.61, 26.34]						R^2 = 0.142** 95% CI[0.01, 0.28]
Dwell Time Enterprising	**0.95****	**[0.36, 1.54]**	**0.37**	**[0.14, 0.61]**	**0.14**	**[-0.01, 0.29]**	**0.38****	
Entry Time Enterprising	0.07	[-0.40, 0.54]	0.03	[-0.20, 0.26]	0.00	[-0.01, 0.02]	0.06	
(Intercept)	16.80**	[4.52, 29.08]						R^2 = 0.084* 95% CI[0.00, 0.23]
Fixation Count Enterpr.	**6.86***	**[1.24, 12.47]**	**0.29**	**[0.05, 0.53]**	**0.08**	**[0.00, 0.23]**	**0.29***	
Criterion: AIST-3 Conventional								
(Intercept)	13.60*	[1.90, 25.31]						R^2 = 0.098* 95% CI[0.00, 0.23]
Dwell Time Conventional	**0.68***	**[0.17, 1.20]**	**0.31**	**[0.08, 0.55]**	**0.10**	**[-0.04, 0.23]**	**0.31****	
Entry Time Conventional	-0.06	[-0.71, 0.58]	-0.02	[-0.26, 0.21]	0.00	[-0.01, 0.01]	-0.01	
(Intercept)	13.96*	[3.01, 24.92]						R^2 = 0.051 95% CI[0.00, 0.18]
Fixation Count Convent.	4.60	[-0.30, 9.49]	0.23	[-0.01, 0.47]	0.05	[0.00, 0.18]	0.23	

3.2 Relationship between image rating and AIST-3 responses

The results of hypothesis H2 are now presented for each RIASEC type. The criterion variable is the AIST-3 data, and the predictor is the image query data (see Table 3).

Significant correlations (p < 0.01) are found for all RIASEC types. The regression models identified correlations between -0.46 ≤ r ≤ -0.82. The negative sign derives from the inverse transformation of the query data. RIASEC type Realistic exhibits the highest correlation and RIASEC type Conventional the lowest. These results indicate a strong coherence between the participants self-reported vocational interest in the standardised AIST-3 and the image query.

Table 3: Summary regression models of H2. Bold values represent significant correlations (**p < 0.01)

Predictor	*b*	*b* 95% CI	*beta*	*beta* 95% CI	sr^2	sr^2 95% CI	*r*	Fit
Criterion: AIST-3 Realistic								
(Intercept)	38.25**	[35.45, 41.04]						R^2 = 0.671**
Query Realistic	**-23.16****	**[-27.18, -19.14]**	**-0.82**	**[-0.96, -0.68]**	**0.67**	**[0.53, 0.75]**	**-0.82****	95% CI[0.53, 0.75]
Criterion: AIST-3 Investigative								
(Intercept)	39.96**	[36.95, 42.97]						R^2 = 0.530**
Query Investigative	**-24.49****	**[-30.21, -18.77]**	**-0.73**	**[-0.90, -0.56]**	**0.53**	**[0.36, 0.64]**	**-0.73****	95% CI[0.36, 0.64]
Criterion: AIST-3 Artistic								
(Intercept)	39.48**	[35.57, 43.38]						R^2 = 0.423**
Query Artistic	**-22.64****	**[-29.19, -16.10]**	**-0.65**	**[-0.84, -0.46]**	**0.42**	**[0.24, 0.56]**	**-0.65****	95% CI[0.24, 0.56]
Criterion: AIST-3 Social								
(Intercept)	40.38**	[36.81, 43.96]						R^2 = 0.343**
Query Social	**-21.49****	**[-28.86, -14.12]**	**-0.59**	**[-0.79, -0.38]**	**0.34**	**[0.16, 0.49]**	**-0.59****	95% CI[0.16, 0.49]
Criterion: AIST-3 Enterprising								
(Intercept)	39.84**	[35.97, 43.70]						R^2 = 0.252**
Query Enterprising	**-15.32****	**[-21.85, -8.78]**	**-0.50**	**[-0.72, -0.29]**	**0.25**	**[0.09, 0.41]**	**-0.50****	95% CI[0.09, 0.41]
Criterion: AIST-3 Conventional								
(Intercept)	31.91**	[27.78, 36.05]						R^2 = 0.207**
Query Conventional	**-15.29****	**[-22.69, -7.89]**	**-0.46**	**[-0.68, -0.23]**	**0.21**	**[0.06, 0.36]**	**-0.46****	95% CI[0.06, 0.36]

3.3 Relationship between eye movements and image rating

This section reports the results of hypothesis H3 for each RIASEC type. The criterion variable is the image query data. Dwell time, fixation count and entry time are the predictors (see Table 4). The regressions show significant correlations between -0.44 ≤ r ≤ -0.67 for the predictor dwell time and -0.38 ≤ r ≤ -0.61 for the predictor fixation count. The negative sign derives from the inverse transformation of the query data. RIASEC type Investigative discloses the highest correlation, and RIASEC types Realistic and Enterprising disclose the lowest. No significant effects were found between entry time and the query data. The 10-fold cross-validation was conducted for each regression model corresponding to the respective RIASEC dimensions. For models using dwell time and entry time as predictors, the mean R^2 values ranged from 0.31 (SD = 0.21) to 0.59 (SD = 0.37), with the highest values observed for Investigative and the lowest for Enterprising. Likewise, in models utilising fixation count as the predictor, mean R^2 values ranged from 0.33 (SD = 0.18) to 0.54 (SD = 0.28), again showing the highest value for Investigative and the lowest for Enterprising. Hypothesis H3 is confirmed for dwell time and fixation count with respect to all RIASEC types. Hypothesis H3 is rejected for entry time as predictor.

Table 4: Summary regression models of H3. Bold values represent significant correlations (**p < 0.01)

Predictor	*b*	*b* 95% CI	*beta*	*beta* 95% CI	sr^2	sr^2 95% CI	*r*	Fit
Criterion: Query Realistic								
(Intercept)	1.03**	[0.64, 1.42]						
Dwell Time Realistic	**-0.04****	**[-0.05, -0.02]**	**-0.42**	**[-0.65, -0.20]**	**0.18**	**[0.01, 0.34]**	**-0.44****	R^2 = 0.201** 95% CI[0.04, 0.35]
Entry Time Realistic	0.01	[-0.01, 0.03]	0.10	[-0.13, 0.32]	0.01	[-0.03, 0.05]	0.16	
(Intercept)	1.27**	[0.95, 1.59]						
Fixation Count Realistic	**-0.33****	**[-0.49, -0.17]**	**-0.45**	**[-0.67, -0.23]**	**0.20**	**[0.05, 0.36]**	**-0.45****	R^2 = 0.202** 95% CI[0.05, 0.36]
Criterion: Query Investigative								
(Intercept)	1.04**	[0.75, 1.32]						
Dwell Time Investig.	**-0.04****	**[-0.06, -0.03]**	**-0.69**	**[-0.87, -0.50]**	**0.46**	**[0.29, 0.64]**	**-0.67****	R^2 = 0.463** 95% CI[0.27, 0.58]
Entry Time Investigative	0.01	[-0.01, 0.03]	0.13	[-0.06, 0.31]	0.02	[-0.03, 0.06]	0.03	
(Intercept)	1.26**	[1.00, 1.53]						
Fixation Count Invest.	**-0.37****	**[-0.48, -0.25]**	**-0.61**	**[-0.81, -0.42]**	**0.38**	**[0.19, 0.52]**	**-0.61****	R^2 = 0.377** 95% CI[0.19, 0.52]
Criterion: Query Artistic								
(Intercept)	1.09**	[0.80, 1.38]						
Dwell Time Artistic	**-0.04****	**[-0.05, -0.03]**	**-0.63**	**[-0.82, -0.44]**	**0.40**	**[0.22, 0.58]**	**-0.63****	R^2 = 0.406** 95% CI[0.21, 0.54]
Entry Time Artistic	0.01	[-0.01, 0.02]	0.08	[-0.12, 0.27]	0.01	[-0.02, 0.03]	0.10	
(Intercept)	1.20**	[0.94, 1.46]						
Fixation Count Artistic	**-0.32****	**[-0.44, -0.19]**	**-0.54**	**[-0.75, -0.33]**	**0.29**	**[0.12, 0.44]**	**-0.54****	R^2 = 0.291** 95% CI[0.12, 0.44]
Criterion: Query Social								
(Intercept)	0.99**	[0.73, 1.25]						
Dwell Time Social	**-0.03****	**[-0.04, -0.02]**	**-0.51**	**[-0.73, -0.30]**	**0.26**	**[0.08, 0.44]**	**-0.51****	R^2 = 0.275** 95% CI[0.09, 0.42]
Entry Time Social	-0.01	[-0.02, 0.01]	-0.10	[-0.31, 0.11]	0.01	[-0.03, 0.05]	-0.11	
(Intercept)	1.05**	[0.78, 1.31]						
Fixation Count Social	**-0.29****	**[-0.41, -0.17]**	**-0.50**	**[-0.72, -0.29]**	**0.25**	**[0.09, 0.41]**	**-0.50****	R^2 = 0.255** 95% CI[0.09, 0.41]
Criterion: Query Enterprising								
(Intercept)	1.04**	[0.70, 1.38]						
Dwell Time Enterprising	**-0.04****	**[-0.06, -0.02]**	**-0.46**	**[-0.68, -0.23]**	**0.21**	**[0.03, 0.38]**	**-0.44****	R^2 = 0.216** 95% CI[0.05, 0.36]
Entry Time Enterprising	0.01	[-0.01, 0.02]	0.14	[-0.09, 0.36]	0.02	[-0.04, 0.07]	0.10	
(Intercept)	1.17**	[0.78, 1.56]						
Fixation Count Enterpr.	**-0.29****	**[-0.47, -0.11]**	**-0.38**	**[-0.61, -0.15]**	**0.14**	**[0.02, 0.30]**	**-0.38****	R^2 = 0.142** 95% CI[0.02, 0.30]
Criterion: Query Conventional								
(Intercept)	1.19**	[0.90, 1.48]						
Dwell Time Conventional	**-0.04****	**[-0.05, -0.03]**	**-0.62**	**[-0.81, -0.42]**	**0.38**	**[0.20, 0.56]**	**-0.62****	R^2 = 0.381** 95% CI[0.19, 0.51]
Entry Time Conventional	-0.00	[-0.02, 0.01]	-0.02	[-0.21, 0.18]	0.00	[-0.01, 0.01]	-0.04	
(Intercept)	1.21**	[0.92, 1.49]						
Fixation Count Convent.	**-0.32****	**[-0.44, -0.19]**	**-0.52**	**[-0.73, -0.31]**	**0.27**	**[0.11, 0.43]**	**-0.52****	R^2 = 0.274** 95% CI[0.11, 0.43]

3.4 Saccades as indicators for career choice certainty

With regard to hypothesis H4, a multilevel linear regression model was run with the combined response time of the AIST-3 items as criterion and saccade duration as well as saccade count as predictors (see Table 5). The results reveal a significant correlation only for the predictor saccade count (r = 0.27). The longer the response time in

AIST-3, the greater is the number of saccades across the whole picture. Though, this correlation is very low. Saccade duration does not show any significant effect. Therefore, hypothesis H4 can be accepted for the parameter saccade count, but not for the parameter saccade duration.

Table 5: Summary regression models of H4. Bold values represent significant correlations (*p < 0.05; **p < 0.01)

Predictor	*b*	*b* 95% CI	*beta*	*beta* 95% CI	*sr²*	*sr²* 95% CI	*r*	Fit
Criterion: Response Time								
(Intercept)	1.53**	[0.72, 2.33]						
Saccade Count	**2.4e-3***	**[2.24e-4, 4.54e-3]**	**0.27**	**[0.03, 0.51]**	**0.07**	**[-0.05, 0.19]**	**0.27***	R^2 = 0.071 95% CI[0.00, 0.20]
Saccade Duration	-0.01	[-0.27, 0.26]	-0.01	[-0.25, 0.24]	0.00	[-0.00, 0.00]	-0.03	

4 Discussion

The aim of this study was to investigate whether eye movement behaviour is suitable to detect the strength of vocational interest and the career choice certainty. In addition, it verified quality criteria for developing a perception-based vocational interest test. Eye tracking was chosen as a measuring instrument to avoid text and therefore language comprehension problems, to minimise biases through insufficient attention or a lack of motivation during the test, and to circumvent socially desirable answers. The results confirmed the improvement of the test procedure. They revealed moderate to high internal consistency of the occupational images and a high prognostic validity.

Our study confirmed the relationship between dwell time and vocational interest across all six RIASEC categories (r = 0.45) and a relationship between fixation count and vocational interest in five out of six RIASEC dimensions (r = 0.43). These results are in line with findings from previous studies (Alshehri & Alghowinem, 2013; Langsdorf et al., 1983; Malitzke et al., 2025a). Not only situational interest can be analysed with eye movements, but also individual interest traits, which are an aspect of our personality. In addition, image stimuli do not have to be shown one after the other, they can also be presented simultaneously as a perceptual decision-making task.

The distribution of participants' favourite vocational interests based on dwell time and fixation count differs slightly from that determined by the standardised test, which may be attributed to bottom-up effects. However, since the results of the salience maps largely rule out this possibility, another explanation is warranted. A tentative interpretation of these findings is that suppressed vocational interests may unconsciously direct attention toward professions that appeal to participants. Eye tracking can uncover these inhibited career aspirations. Contrary to our expectations, no significant correlations were found between entry time and vocational interest. This lack of correlation can be attributed to the random placement of the AOIs in each session, which hindered direct comparisons between the variables.

Our findings provide further evidence for the effectiveness of image-based vocational interest assessments. The query showed a strong correlation across all RIASEC categories with AIST-3 data ($r = 0.63$) and with the eye tracking parameters dwell time ($r = 0.55$) as well as fixation count ($r = 0.50$). The latter result is expected, as both eye movements and the query focus on the same visual stimuli. The correlation with AIST-3 data is particularly intriguing, as evaluating images of professions alone may reveal individuals' vocational interests. We encourage researchers and test developers to expand their methods beyond scale-based verbal tests and incorporate perception-based analyses, because of the faster test procedure, the recording of involuntary behavioural reactions and the gamified approach.

The 10-fold cross-validation results indicate that predictive accuracy varies by predictor and RIASEC dimension. Models using dwell time outperformed those using fixation count (mean $R^2 = 0.42$ vs. 0.35), suggesting that dwell time is a more informative predictor of vocational interests via eye tracking. Models with image-based query as the criterion showed higher R^2 values than those using AIST-3, for both predictors. This implies that image-based queries capture intuitive, perceptual aspects of interest, whereas the AIST-3 reflects more rational, conscious processes–possibly explaining its lower predictive performance. Predictive validity also differed across RIASEC dimensions. Investigative and Artistic types revealed consistently stronger prediction across models, while Realistic and Enterprising exhibited lower accuracy. These differences may relate to construct validity, participant engagement, and measurement reliability. Overall, designing eye-tracking-based vocational assessments should consider the varying predictability of the RIASEC dimensions and the reliability of the items, particularly when developing image stimuli. In addition, eye tracking can be a suitable alternative to the non-verbal, image-based tests like the GPII-R (Geist, 1964) or the F-I-T (Jungo & Toggweiler, 2019).

A further interesting finding was the significant correlation between saccade count and the response time of the AIST-3 ($r = 0.27$). Previous literature has explored the role of fixation counts in decision making (Horstmann et al., 2009; Orquin & Mueller Loose, 2013). Given that saccade count is directly related to fixation count, it is not surprising that it also correlates significantly with response time. This finding highlights the relevance of eye movements and response time as an indicator of choice certainty. Participants' effort and motivation have a major influence on response time (Wise & Kong, 2005). More research is required to clarify the role of eye movements and response time in the assessment of vocational interest.

The uneven distribution of participants' field of vocational interests is one limitation of the study. This disparity should be taken into account when interpreting the findings. In this study, only the first primary RIASEC dimension was used to link interest with perception. Normally, a three-letter code (RIASEC code) is utilised to define the vocational interest of individuals in the career counselling process. To reduce the complexity of the analysis, however, only one dimension was considered. The reciprocal influence of the different tasks cannot be fully ruled out. This is a limitation of the study. Future studies are planned with a time interval between the eye tracking task and the self-reported vocational interest tests.

5 Conclusion

This study has shown that eye movement behaviour is connected to vocational interests. The findings expand our knowledge of the influence of personality traits like vocational interest on visual perception. Earlier studies have investigated eye movement and personality traits for whole pictures or single objects. This study goes beyond this and shows that vocational interests as an individual interest trait can be measured in eye movement behaviour within complex images showing a set of vocational scenes. The general conclusion drawn from the analysis indicates medium to high correlations between vocational interest and dwell time, as well as fixation count. The more interested the participants are in a profession, the longer the dwell time and higher the fixation count. Notably, this study demonstrated that images do not need to be presented sequentially; displaying multiple occupational pictures simultaneously enhances the test's effectiveness and efficiency. Furthermore, saccade count can be a behaviour-based measurement value for the career choice certainty. There is a significant research potential in this area. An image-based query can determine vocational interest too, no matter if the type of representation is a photograph, an illustration, or a pictogram. In practice, assessing vocational interest via eye tracking can avoid biases of traditional vocational interest questionnaires. The eye tracking procedure quickly identifies vocational interests and saves valuable time, providing personalised advice for further career guidance. Future research will have to investigate to what extent vocational interest assessment via eye tracking can be standardised and used in career counselling.

EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

Mathematisch-Naturwissenschaftliche Fakultät

Declaration according to § 5 Abs. 2 No. 8

of the PhD regulations of the Faculty of Science

-Collaborative Publications-

The following chapter (Chapter 2.3) consists of a manuscript that was co-authored by Stephan Schwan and Constance Richter.

The manuscript 'Assessing Career Choice Certainty: Values and Limitations of Eye Tracking Metrics and Response Time' is currently under review.

The proportional contributions to the manuscript are presented in the subsequent table.

Authors	Author position	Scientific ideas (%)	Data generation (%)	Analysis and Interpretation (%)	Paper writing (%)
Patricia Malitzke	First	80	100	90	90
Stephan Schwan	Second	10	0	5	5
Constance Richter	Third	10	0	5	5
Title of the paper	Assessing Career Choice Certainty: Values and Limitations of Eye Tracking Metrics and Response Time				
Status in publication process	Under Review				

2.3 Study 3 – Manuscript 3

Assessing Career Choice Certainty: Values and Limitations of Eye Tracking Metrics and Response Time

1 Introduction

The foundation of a successful career choice lies in a deep understanding of one's vocational interests, paired with effective guidance in selecting a suitable career path. Traditionally, career counsellors have relied on standardised inventories to evaluate career choice decisions. While the conventional methods have proven their value over time, they are not without limitations. Problems such as extreme response styles (Aichholzer, 2013; Newcomb et al., 1986), varying levels of motivation (Süß & Schmiedek, 2000), and dependence on language proficiency can compromise the accuracy of self-reported assessments.

In light of these challenges, our study explored a novel approach to assess career choice certainty in adolescence. We investigated whether behavioural parameters, such as eye movements and response time, can serve as reliable indicators of career decision certainty. The following sections offer an overview of existing research on eye movements and response time, highlighting their connection to personality traits, in particular vocational interests, and their role in assessing decision-making certainty.

1.1 Visual perception and decision certainty

Decision-making has been the focus of extensive research, including studies that analyse eye movement behaviour as an indicator of the preferred options or the decision certainty. To choose the right option, decision makers have to search for specific information. This information search behaviour can be evaluated with eye tracking as a process tracing method. A number of scholars carried out empirical studies on binocular gaze data and decision-making processes. They showed that fixation behaviour and saccadic behaviour are influenced by the decision (un)certainty of the participants (Glaholt & Reingold, 2011; Horstmann et al., 2009; Wedel et al., 2023). Uncertainty for example increases the working memory load and thus leads to longer saccades and a greater number of fixations (Orquin & Mueller Loose, 2013). On the other hand, studies identified fixation duration, fixation frequency, saccade amplitude, pupil diameter and gaze shifts as suitable parameters to evaluate participants decision certainty (Brunyé & Gardony, 2017; Uggeldahl et al., 2016).

A large research base on perceptual decision-making can be found in the field of economics and neurophysiology. Attempts have been made to predict decision-making behaviour prior to the actual response with the help of a gaze analysis. An important theory is the Gaze Cascades model by Shimojo et al. It states that the decision maker first shifts their gaze between the possible options. At the end, the gaze focusses on their choice right before they announce their favourite option. This behaviour has been detected for several stimuli, like faces and random shapes (Shimojo et al., 2003). Further studies demonstrated that people tend to focus on their favourite stimuli longer over the entire observing time, regardless of the age of the participants (Saito et al., 2017). The shift between novel objects (exploration) and earlier fixated objects (exploitation) is neurophysiological evidence: Refixations can serve as a resource to reduce sensory uncertainty in complex images with areas of high salience (Spering, 2022). These findings mostly apply to free-viewing search tasks. In our study, we went beyond these findings and used a forced-choice task with complex images.

1.2 Response time and decision certainty

Response time is a valuable predictor for decision-making in personality assessment, problem solving and market research. For example, incorporating response time as a measured variable in personality assessments can be used to improve estimation accuracy (Guo et al., 2024). The effort and motivation while answering digital tests and questionnaires can be analysed with response time (Wise & Kong, 2005). Response time is often utilised for tasks with rating scales. Research on this topic revealed systematic biases, called the response styles. They are latent personality traits that explain participants preferences to certain items of the rating scales (Paulhus, 1991). For instance, extreme response styles (ERS) increase with high decisiveness (Naemi et al., 2009). The existing literature emphasises that longer response times may be associated with lower decision certainty (Henninger & Plieninger, 2021; Kiani et al., 2014; Kim & Bolt, 2023). These findings highlight the critical role of response time as an indicator of underlying cognitive and motivational processes in decision-making. Understanding the relationship between response time and decision certainty can provide deeper insight into individual differences in decision-making behaviour. To date, no study has looked specifically at response time in vocational interest tests. In this paper, we attempt to shed some light on this research gap.

1.3 Visual interest and vocational interest

Visual interest and attention are related but distinct constructs. While visual interest can direct attentional focus and gaze, attention may also be allocated to stimuli lacking intrinsic interest (bottom-up processes). Thus, attention can occur independently of interest. Interest represents a higher-order cognitive and affective variable, with visual interest reflecting an individual's evaluative preference for visual stimuli (Ackerman, 1996; Savazzi et al., 2014). Visual interest falls under the broader category of interest state, a context-dependent, affective condition. In contrast, interest trait refers to enduring, personality-based dispositions, such as vocational interest, which influences long-term preferences for specific occupational domains (Schermer, 2017). Visual interest is reflected in long saccades (Soleymani & Mortillaro, 2018), and situational interest can be analysed with fixation time and viewing time (Evans & Day, 1971; Langsdorf et al., 1983; Silvia, 2005). It is not far-fetched that there is a connection between eye movement behaviour and vocational aspects. Several scholars have found evidence that vocational performance and expertise can be read from gaze behaviour (Aljehane et al., 2023; Francuz et al., 2018; Reingold & Sheridan, 2011).

Normally, career choice is measured with standardised tests. These tests are often based on vocational interest theories. Holland (1997) invented the internationally best known theory of vocational interest: the RIASEC model. It remains a cornerstone in today's career counselling, work psychology, and organisational psychology. Holland's theory of career choice classifies both individuals and work environments into six categories, commonly known as the RIASEC types: Realistic, Investigative, Artistic, Social, Enterprising, and Conventional. The central premise of the model is the alignment of individuals' vocational interests with corresponding occupational environments to optimise career satisfaction and success. Each RIASEC dimension is associated with unique cognitive abilities and approaches to process information, and enable individuals to navigate distinct environmental challenges and tasks (Holland, 1997).

German counsellors use inventories like the *EXPLORIX®* (Jörin Fux et al., 2004) or the *Allgemeiner-Interessen-Struktur-Test AIST-3* (General Interest Structure-Test) (Bergmann & Eder, 2019) that are based on Holland's RIASEC model. Furthermore, there are tests that utilise images and photographs to identify career preferences, like *The Geist Picture Interest Inventory GPII-R* (Geist, 1964) or the *Foto-Interessen-*

Test F-I-T (Photo-Interest-Test) (Jungo & Toggweiler, 2019). These questionnaires are effective and valid, but also have limitations. On average, participants require approximately 15 minutes to complete up to 60 items. This can lead to attentional-based biases. Moreover, responses can be distorted through social desirability or acquiescent answers (Gordon, 1987; Kreitchmann et al., 2019). This applies especially to adolescents who have not chosen their preferred career yet. Another critical aspect is the language dependency that can lead to comprehension problems. Consequently, there is a lot of potential to improve the process of assessing career choice; for example, by using behaviour-based measurement methods.

1.4 Previous studies

There are two studies that already analysed the relationship between eye movement behaviour and vocational interest (Malitzke et al., 2025a, 2025b). Both studies used complex images to detect vocational interests according to Holland's RIASEC types. The picture stimuli consisted of six occupations that were presented simultaneously. Observers were tasked to find their most preferred professional activity among the depicted options. An eye tracker recorded several fixational and saccadic parameters. These perceptual measurements were correlated with self-reported vocational interest. To determine the latter, a standardised vocational interest test (AIST-3) and an image rating were used. The two studies differed in the test procedure, and the number and type of the presented occupations. The study of Malitzke et al. (2025a) revealed significant, moderate correlations in five out of six RIASEC dimensions between the AIST-3 scores and the eye tracking parameter dwell time and fixation count. The more the participants were interested in a certain occupation the higher was the dwell time and the fixation count in the corresponding picture area. In addition, the dwell time and fixation count correlated with the responses of the image rating (Malitzke et al., 2025a). In contrast to this, the study of Malitzke et al. (2025b) changed the test procedure, so that an internal consistency of the image rating could be determined. Participants visually explored two image stimuli with six occupations each. Therefore, the subjects had 12 vocational activities to choose from. Significant correlations were found for all six RIASEC dimensions. The correlations between the self-reported vocational interest in the AIST-3 and dwell time as well as fixation count remained similar to the finding of Malitzke et al. (2025b). The same applied to the relationship between image rating and dwell time respectively fixation count. Furthermore, this study examined the career choice certainty. It used the response time of AIST-3 items as an indirect measurement of choice certainty. This parameter was correlated with saccadic metrics. Only the saccade count significantly correlated with response time, but the correlations was low. These findings were in contrast to results from other studies on choice certainty. One possible reason for this could have been the small sample size (Malitzke et al., 2025b). Therefore, the present study aimed to analyse the relationship between career choice certainty and both eye movement behaviour and response time in verbal tests once more; with a larger sample size and a greater number of variables.

1.5 Present research

In this study, we consider the extent to which career choice certainty and the strength of vocational interest can be analysed by affective behaviour like eye movements and response time. We reused the eye tracking stimuli of Malitzke et al. (2025b), because these images encourage participants to make quick and intuitive decisions. Eye movements in terms of fixation patterns, saccadic patterns and alternating observation behaviour was compared with self-reported choice certainty and response times in a verbal career choice test. Moreover, we evaluated the correlation between image-based certainty ratings and verbal certainty ratings. In a subsidiary analysis we evaluated the influence of the strength of vocational interest in viewing behaviour, in particular the dwell time and fixation count according to occupational areas of interest. We chose dwell time, because previous literature identified fixation time and viewing time as suitable parameters to assess interest (Evans & Day, 1971; Langsdorf et al., 1983).

Four preregistered hypotheses and one explorative hypothesis were defined (AsPredicted number: #160264):

RQ1: Can eye movement parameters be used to assess certainty in career choice?
Hypothesis H1: There are significant correlations between the self-reported choice certainty of vocational interests and eye movement behaviour while looking at pictures of RIASEC types in terms of number of saccades, saccade velocity, AOI revisits and fixation duration according to the AOIs.

RQ2: Can visual methods assess certainty in career choice as effectively as verbal methods?
Hypothesis H2: For each of the six types of RIASEC, there is a positive correlation between the choice certainty of a standardised vocational interest test and the choice certainty of an occupation-related image evaluation.

RQ3: Does the response time of a standardised vocational interest test measure career choice certainty?
Hypothesis H3: For each of the six types of RIASEC, there is a negative correlation between response time in a standardised vocational interest test and choice certainty in a standardised vocational interest test.

RQ4: Is there a relationship between response time and eye movement behaviour?

Hypothesis H4: There are significant correlations between response time in a standardised vocational interest test and eye movement behaviour while looking at pictures of RIASEC types in terms of number of saccades, saccade velocity, AOI revisits and fixation duration according to the AOIs.

Additional research question RQ5 (without preregistration): Is there a relationship between the strength of vocational interest and eye movement behaviour?

Explorative Hypothesis H5: For each of the six types of RIASEC, there is a positive correlation between the strength of vocational interest and dwell time as well as fixation count in the corresponding image area.

2 Method

2.1 Participants

In advance, an a priori power analysis was conducted to calculate the sample size. A minimum number of 119 participants was mandatory to ensure a medium effect ($f = 0.15$) with a power of 0.95 ($\alpha = 0.05$). In sum, 154 adolescents participated in the present study. Three data sets were removed for which the WIFI connection was too slow; two data sets were removed because the eye tracker did not record any data; and one data set was removed because the participant has wilfully falsified the results. In the end, 148 data sets were statistically analysed (male: 65; female: 83). The unequal gender distribution should be considered when interpreting the results. The average age of the participants was 17.01 years ($SD = 0.926$). The selection criteria of the participants were defined: (1) an age between 16 and 19 years, (2) native-level German language skills to avoid comprehension problems in the verbal tests, (3) no visual impairments, (4) a sufficient eye tracking calibration score, and (5) the complete answering of all test items. Participants were recruited from seven different (specialised) secondary and high schools and five career fairs in the local area of Aalen (Germany). All subjects gave their informed consent and knew that they could stop data collection at any time of the study procedure. An approval of the ethics committee of the University of Tübingen (Germany) was preserved (LEK 2022/004).

2.2 Pictorial stimuli

An illustrator created two detailed images with six areas of interest (AOI), each representing professions in conformity with Holland's RIASEC types. Illustrations were chosen for a gamification approach and to use stylised representations of the vocational activities, characters and interactions. Furthermore, it simplified the randomisation of the AOI positions. A limit of six professions was chosen for each image to reduce the range of career choices (Nurcahyo et al., 2019). Stimulus 1 shows a painter (Artistic), a carpenter (Realistic), nurses and doctors (Social), a bank employee (Conventional), a cognitive researcher (Investigative) and entrepreneurs (Enterprising). Stimulus 2 displays a salesperson (Enterprising), a musician (Artistic), a mechanic (Realistic), a kindergarden teacher (Social), office administrators (Conventional) and laboratory assistants (Investigative) (see Figure 1). Using Adobe Photoshop, six different versions of each stimulus were designed, with the positions of each AOI randomly arranged (see Appendix A.1 and A.2). The depictions were adjusted to reflect the specific work settings, social interactions, colour schemes, and team group sizes associated with each profession. The characters represent cultural diversity and inclusivity, avoiding stereotypes related to gender or age. Career paths were chosen which matched different school-leaving qualifications. In this way, the adolescents were offered a wide variety of potentially interesting jobs.

Variant of stimulus 1
clockwise from top left: Social, Conventional, Investigative, Realistic, Artistic, Enterprising
©Aalen University

Variant of stimulus 2
clockwise from top left: Conventional, Investigative, Enterprising, Social, Realistic, Artistic
©Aalen University

Figure 1: variants of the eye tracking stimuli 1 and 2

2.3 Data collection

Data was collected from four different sources. Visual interest and perceptual decision certainty were measured with eye tracking data and an image-based evaluation. Eye movements were recorded with a remote eye tracker. The career choice certainty according to the viewed stimuli was queried by using a 5-point Likert scale in a digital query. A second query questioned the certainty according to the answers given in a standardised vocational interest test (AIST-3). Furthermore, the response time of the AIST-3 items was collected. The data collection and variables are described in more detail in the following sections.

2.3.1 Eye tracking

For the eye tracking test, a chin and forehead rest was used to provide bias through a change of position of the adolescents. Both stimuli were displayed on a 15-inch Dell notebook screen with a resolution of 1920 x 1080 pixels. Each AOI, representing a different RIASEC type, measured 416 x 416 pixels. Binocular gaze data from the right eye was collected using a state-of-the-art remote eye tracker from SensoMotoric Instruments (SMI) at 60Hz. The eye tracker has a reported gaze estimation accuracy of 0.4 °. To achieve high-quality eye-tracking data, each participant completed a calibration process using nine points, followed by a validation process with four points, prior to the data collection. The calibration-validation process was successful if the offset was less than 0.8 °. The following eye tracking data according to the AOIs were recorded: fixation duration, AOI revisits, dwell time, and fixation count. The following data depending on the whole images was recorded: number and velocity of the saccades. These eye tracking parameters were chosen because of the findings of previous studies (see Section 1.3).

2.3.2 Image-based certainty evaluation

A short digital questionnaire was designed to determine the participants' career choice certainty in line with the viewed stimuli. Participants rated each AOI on a 5-point Likert scale according to their interest in performing the associated vocational task. Afterwards, they indicated whether they were certain or uncertain about their previous statement. The scale ranged from 1 = 'not certain at all' to 5 = 'very certain'. Participants evaluated the 12 AOIs sequentially, providing two certainty ratings for each RIASEC dimension.

2.3.3 AIST-3-based certainty evaluation

To verify the results of the image-based certainty query, the career choice certainty was analysed with an evaluation of the certainty of the AIST-3 responses. The AIST-3 was chosen because of its extensive research base and fast execution within 15 minutes. The inventory consists of 60 items rated on a 5-point Likert scale (Bergmann & Eder, 2019). The test was carried out online with the Hogrefe Test System

(HTS). After the participants completed the AIST-3, they rated their certainty according to their previous responses in the AIST-3. The study leader provided a brief overview of the AIST-3 items and the RIASEC types and then asked the participants how certain they were about their interest in the corresponding RIASEC dimension. They rated on a 5-point Likert scale ranged from 1 = 'not certain at all' to 5 = 'very certain' their decision certainty. In total, the adolescents gave six ratings of decision certainty, one per RIASEC type. The study leader verbally queried the participants choice certainty and wrote the answers on a paper form. This change of test style was done to avoid decreasing attention and motivation of the participants, because the collection of the eye tracking data and the AIST-3 evaluation took around twenty minutes.

2.3.4 AIST-3 response time

Data from several studies suggest that response time is a suitable parameter for the certainty of choice in questionnaires (Börger, 2016; Uggeldahl et al., 2016). This study used the AIST-3 response times per RIASEC type in order to gain insights into participants career choice certainty. The response times of the 60 AIST-3 items were exported from the Hogrefe Test System. The mean values were calculated according to the six RIASEC types. In addition, a mean value of all 60 response times (response time total) was cumulated for every participant.

2.4 Procedure

In this field study, we collected data from pupils in different schools and career fairs. In advance, the participants were not aware of the purpose of the study and the data collection procedure. This was done to prevent possible impact or priming effects on their responses. It was made sure that all participants took part under the same environmental conditions. Therefore, factors such as the influence of the position of the light and the table facing an empty wall have been taken into account. One study supervisor and one participant sat next to each other on the same table. Initially, the adolescents reviewed the study information, provided their written consent, and confirmed their awareness of data privacy. To maintain anonymity, each participant was assigned a unique identification number (ID). All data was recorded on the same laptop.

The test procedure comprised two main parts: the eye tracking part and the AIST-3 part for verification (see Figure 2). At the end, the study leader elucidated the eye tracking results (scan paths) to the participants as an incentive. This information could be used by the adolescents for their further career orientation.

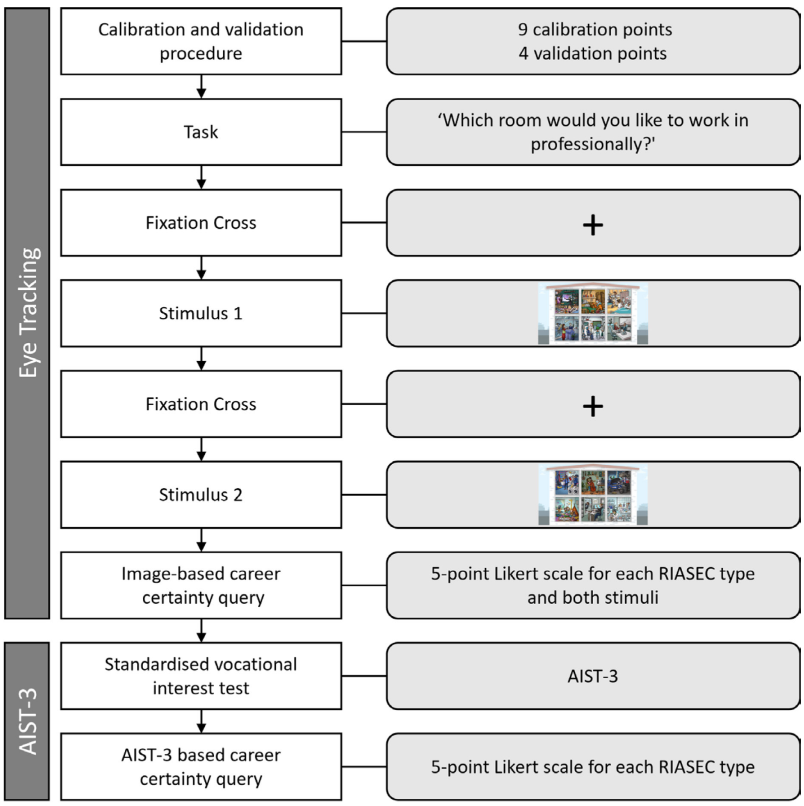


Figure 2: Flow chart of the test procedure

2.5 Data analysis

The exported data from the SMI BeGaze eye tracking program was recorded from two stimuli. The data for AOI revisits, fixation duration, dwell time, fixation count, saccade count, and saccade velocity for each stimulus were cumulated to mean values. Revisits, fixation duration, dwell time and fixation count refer to the single AOIs respectively RIASEC dimensions. Saccade count and saccade velocity refer to the entire stimuli without AOIs. This was done to analyse the eye movement behaviour a) while making a perceptual decision of the preferred AOI and b) while perceiving the entire stimuli during a search task. The data of the image-based query was also combined for the two stimuli. The AIST-3 consists of 60 items; 10 per RIASEC type. We cumulated the mean values of the response times for each RIASEC type and an additional score over all RIASEC dimensions for each participant. The verbal query had only one item per RIASEC dimension, so no data cumulation was done.

To rule out possible bottom-up effects like distractions through colour, shapes, orientations or contrasts, salience maps were created with MATLAB (Itti et al., 1998). The comparison of the salience maps with the results of the participants' scan paths indicated that the search task mainly guided the subjects' eyes while observing the stimuli. Design features played a minor role in the search task.

Linear regression models were calculated to investigate the relationship between career choice certainty and behavioural parameters (see Table 1). All models were tested according to the Akaike Information Criterion (AIC) with the R function 'screen-reg' (Leifeld, 2013). This was done, because the intercorrelation matrices showed high co-linearity between dwell time and fixation count ($0.75 \leq r \leq 0.94$), and between fixation duration and saccade count ($r = 0.72$). The models with the lowest AIC values were run with the R package lm4 of Bates et al. for each RIASEC type and for the whole stimulus (Bates et al., 2015). We calculated two model sets for hypothesis H1, to examine the relationship between (un)certainty and eye movement behaviour. The first set consisted of one model for each AOI with the revisits and fixation duration [ms] as predictors and the image-based query as criterion. For the second set, we run one regression model for the entire stimuli (without AOIs) with the number of saccades and saccade velocity [°/s] as predictors and the image-based certainty query (accumulated over the single AOIs) as criterion. For hypothesis H2, we conducted one model for each RIASEC type, with the AIST-3-based certainty query as predictor and the image-based certainty query as criterion. These models should analyse the relationship between the certainty measured in an image-rating and in a scale-based test. For hypothesis H3, we calculated one model for each RIASEC type with the AIST-3 response time as predictor and the AIST-3-based certainty query as criterion. These regressions were executed to analyse the suitability of response time as a predictor for career choice certainty. For hypothesis H4, we created two model sets: one set with models for each RIASEC type with the AOI revisits and AOI fixation duration [ms] as predictors and the AIST-3 response time as criterion. The second model set included the number of saccades and saccade velocity [°/s] across the entire stimuli as predictors and the AIST-3 response time (accumulated over the AOIs) as criterion. These model sets were run to test a possible correlation between the indirect certainty measures response time and eye movements. Additionally for hypothesis H5, we calculated one model for each RIASEC type with the dwell time and fixation count as predictors and the AIST-3 scores as criterion. This was done to analyse the relationship between the strength of vocational interest and the eye movement behaviour.

Table 1: Overview hypotheses, regression models and variables

	Simple linear regression		Multilevel linear regression	
	Criterion	**Predictor**	**Criterion**	**Predictor**
H1	-	-	Image-based certainty query	AOI revisits, AOI fixation duration
				Saccade count, Saccade velocity
H2	Image-based certainty query	AIST-based certainty query	-	-
H3	AIST-based certainty query	Response time	-	-
H4			Response time	AOI revisits, AOI fixation duration
				Saccade count, Saccade velocity
H5	AIST-3 scores	AOI dwell time	-	-
		AOI fixation Count		

The residuals of the models were not normally distributed, which is a requirement for linear regressions. We tested several data transformations for the variables and have chosen the best options: revisits, dwell time and fixation count–cubic root transformation, fixation duration and saccade velocity–invers transformation. The variable response time showed a Weibull distribution. This is consistent with previous studies verifying the Weibull distribution for response times (Gvozdenko, 2010; Tatsuoka & Tatsuoka, 1978). We logarithmic transformed the response time, as several authors recommended in their studies (Henninger & Plieninger, 2021; Kim & Bolt, 2023). The imaged-based certainty query and the AIST-3-based certainty query did not show normal distribution as well. We tried several data transformations, but this led to even worse results of the normal distribution of the residuals. Therefore, we did not transform the query variables. Saccade count was the only variable that was normally distributed and did not need a transformation. In addition, we calculated a bootstrapping model and a mixed-effects model because of the left-skewed data distribution. However, this did not provide any other results than the transformed regression models.

3 Results

This chapter begins by offering a quantitative analysis of the relationship between vocational interest and eye movement behaviour (explorative hypothesis H5 and previous studies). The remaining sections present the results of the four preregistered hypotheses.

3.1 Vocational interest and eye movements

Before we reveal the results for the decision certainty, this section provides an insight into the relationship of the strength of vocational interest and eye movement behaviour. Therefore, the results of the explorative hypothesis H5 are presented (see Table 2). Additionally, Table 3 outlines the correlations between eye movement parameters (dwell time and fixation count) and self-reported vocational interest (AIST-3 scores and image rating scores) across the study of Malitzke et al. (2025a), the study of Malitzke et al. (2025b) and the present study.

Table 2 reports the results of the linear regression models according to the RIASEC AOIs. Dwell time and fixation count were the predictors, and the AIST-3 scores were the criterion. Dimension Realistic exhibited the highest correlations for dwell time ($r = 0.63$) and fixation count ($r = 0.59$). Enterprising revealed the lowest correlations for dwell time ($r = 0.32$) and fixation count ($r = 0.35$). All models revealed a significant effect ($p < 0.01$). Therefore, dwell time as well as fixation count can be suitable predictors for the strength of vocational interest.

Table 2: Summary regression models of explorative hypothesis H5. Bold values represent significant correlations (**p < 0.01)

Predictor	*b*	*b* 95% CI [LL, UL]	*beta*	*beta* 95% CI [LL, UL]	sr^2	sr^2 95% CI [LL, UL]	*r*	Fit
AIST-3 Realistic as the criterion								
(Intercept)	19.85**	[18.39, 21.31]						R^2 = 0.403**
Dwell Time Realistic	**0.00****	**[0.00, 0.00]**	**0.63**	**[0.51, 0.76]**	**0.40**	**[0.28, 0.50]**	**0.63****	95% CI [0.28, 0.50]
(Intercept)	18.41**	[16.58, 20.24]						R^2 = 0.351**
Fixation Count Realistic	**0.72****	**[0.56, 0.88]**	**0.59**	**[0.46, 0.72]**	**0.35**	**[0.23, 0.45]**	**0.59****	95% CI [0.23, 0.45]
AIST-3 Investigative as the criterion								
(Intercept)	20.63**	[18.85, 22.41]						R^2 = 0.294**
Dwell Time Investigative	**0.00****	**[0.00, 0.00]**	**0.54**	**[0.40, 0.68]**	**0.29**	**[0.18, 0.40]**	**0.54****	95% CI [0.18, 0.40]
(Intercept)	19.87**	[17.56, 22.18]						R^2 = 0.214**
Fixation Count Invest.	**0.63****	**[0.43, 0.82]**	**0.46**	**[0.32, 0.61]**	**0.21**	**[0.11, 0.32]**	**0.46****	95% CI [0.11, 0.32]
AIST-3 Artistic as the criterion								
(Intercept)	18.04**	[16.04, 20.03]						R^2 = 0.355**
Dwell Time Artistic	**0.00****	**[0.00, 0.00]**	**0.60**	**[0.46, 0.73]**	**0.36**	**[0.24, 0.46]**	**0.60****	95% CI [0.24, 0.46]
(Intercept)	17.16**	[14.57, 19.75]						R^2 = 0.263**
Fixation Count Artistic	**0.92****	**[0.67, 1.17]**	**0.51**	**[0.37, 0.65]**	**0.26**	**[0.15, 0.37]**	**0.51****	95% CI [0.15, 0.37]
AIST-3 Social as the criterion								
(Intercept)	22.35**	[20.54, 24.16]						R^2 = 0.303**
Dwell Time Social	**0.00****	**[0.00, 0.00]**	**0.55**	**[0.41, 0.69]**	**0.30**	**[0.18, 0.41]**	**0.55****	95% CI [0.18, 0.41]
(Intercept)	19.67**	[17.44, 21.91]						R^2 = 0.333**
Fixation Count Social	**0.92****	**[0.70, 1.13]**	**0.58**	**[0.44, 0.71]**	**0.33**	**[0.21, 0.44]**	**0.58****	95% CI [0.21, 0.44]
AIST-3 Enterprising as the criterion								
(Intercept)	26.29**	[23.83, 28.75]						R^2 = 0.106**
Dwell Time Enterprising	**0.00****	**[0.00, 0.00]**	**0.32**	**[0.17, 0.48]**	**0.11**	**[0.03, 0.20]**	**0.32****	95% CI [0.03, 0.20]
(Intercept)	25.23**	[22.49, 27.96]						R^2 = 0.121**
Fixation Count Enterpr.	**0.50****	**[0.28, 0.72]**	**0.35**	**[0.19, 0.50]**	**0.12**	**[0.04, 0.22]**	**0.35****	95% CI [0.04, 0.22]
AIST-3 Conventional as the criterion								
(Intercept)	19.70**	[17.37, 22.02]						R^2 = 0.200**
Dwell Time Conventional	**0.00****	**[0.00, 0.00]**	**0.45**	**[0.30, 0.59]**	**0.20**	**[0.10, 0.31]**	**0.45****	95% CI [0.10, 0.31]
(Intercept)	19.12**	[16.19, 22.05]						R^2 = 0.147**
Fixation Count Convent.	**0.58****	**[0.35, 0.80]**	**0.38**	**[0.23, 0.53]**	**0.15**	**[0.06, 0.25]**	**0.38****	95% CI [0.06, 0.25]

A comparison of the results of Malitzke et al. (2025a), Malitzke et al. (2025b) and the present study exhibited significant correlations across all three studies (see Table 3). Dwell time and fixation count were correlated with the AIST-3 scores, as well as the image query scores. The image query assessed the strength of vocational interest with a 5-point Likert scale. The participants rated their interest according to the six RI-ASEC AOIs. The correlations for dwell time were slightly higher than the correlations for fixation count (~ 0.05). In general, the correlations were medium (r = 0.29) to high (r = 0.67). Significant correlations were found for smaller samples (n = 67) and larger samples (n = 148). In the study of Malitzke et al. (2025b) and the present study all RIASEC dimensions indicated a considerable effect for variable dwell time.

Table 3: Comparison of the correlation results of the three studies (*p < 0.05; **p < 0.01)

RIASEC Type	Predictor: Dwell Time 1. Study (n=102)	2. Study (n=67)	3. Study (n=148)	Predictor: Fixation Count 1. Study	2. Study	3. Study
Criterion: AIST-3						
Realistic	0.52**	0.42**	0.63**	0.35**	0.39**	0.46**
Investigative	0.49**	0.65**	0.54**	0.43**	0.60**	0.51**
Artistic	0.49**	0.51**	0.60**	0.36**	0.45**	0.51**
Social	0.44**	0.45**	0.55**	0.39**	0.40**	0.58**
Enterprising	0.45**	0.38**	0.32**	0.39**	0.29*	0.35**
Conventional	0.03	0.31**	0.45**	0.03	0.23	0.38**
Criterion: image query						
Realistic	0.53**	0.44**	0.54**	0.45**	0.45**	0.53**
Investigative	0.54**	0.67**	0.49**	0.42**	0.61**	0.45**
Artistic	0.50**	0.63**	0.52**	0.44**	0.54**	0.42**
Social	0.64**	0.51**	0.47**	0.55**	0.50**	0.46**
Enterprising	0.58**	0.44**	0.51**	0.51**	0.38**	0.43**
Conventional	0.07	0.62**	0.51**	0.04	0.52**	0.48**

3.2 Image-based certainty statements and eye movements

In this section, the relationship between the certainty in making career decision and the eye movement behaviour is quantitatively assessed. We calculated two models for the hypothesis H1. The predictors for model set 1 were AOI revisits and AOI fixation duration (see Table 4). The predictors for model 2 were saccade count and saccade velocity (see Table 5). The criterion variable for both models was the image-based certainty query. The results of the two stimuli were cumulated for all relevant variables. Model set 1 refers to the AOIs. Model 2 addresses the entire stimuli without AOIs.

Contrary to our expectation, no significant correlations were obtained between the image-based certainty query and the eye movement parameters. The correlations were low or non-existent for all models. Hypothesis H1 can be rejected. Our results provide no evidence of a relationship between career choice certainty and AOI revisits, fixation duration, saccade count, and saccade velocity for adolescents.

Table 4: Summary regression model set 1 of H1 for each RIASEC type

Predictor	b	b 95% CI [LL, UL]	beta	beta 95% CI [LL, UL]	sr^2	sr^2 95% CI [LL, UL]	r	Fit
Image-based certainty query (Realistic) as the criterion								
(Intercept)	4.27**	[3.85, 4.70]						
Revisits Realistic	0.19	[-0.14, 0.52]	0.09	[-0.07, 0.26]	0.01	[-0.02, 0.04]	0.10	R^2 = 0.010 95% CI[0.00, 0.05]
Fixation Duration Realistic	14.54	[-143.00, 172.09]	0.02	[-0.15, 0.18]	0.00	[-0.00, 0.01]	0.03	
Image-based certainty query (Investigative) as the criterion								
(Intercept)	4.06**	[1.36, 6.76]						
Revisits Investigative	0.02	[-0.38, 0.43]	0.01	[-0.15, 0.17]	0.00	[-0.00, 0.00]	0.01	R^2 = 0.000 95% CI[0.00, 10.00]
Fixation Duration Investigative	0.01	[-0.42, 0.44]	0.00	[-0.16, 0.17]	0.00	[-0.00, 0.00]	0.00	
Image-based certainty query (Artistic) as the criterion								
(Intercept)	6.03**	[3.71, 8.35]						
Revisits Artistic	-0.24	[-0.65, 0.16]	-0.10	[-0.26, 0.07]	0.01	[-0.02, 0.04]	-0.12	R^2 = 0.024 95% CI[0.00, 0.08]
Fixation Duration Artistic	-0.25	[-0.64, 0.15]	-0.10	[-0.27, 0.06]	0.01	[-0.02, 0.04]	-0.12	
Image-based certainty query (Social) as the criterion								
(Intercept)	3.64**	[0.91, 6.37]						
Revisits Social	0.35	[-0.10, 0.80]	0.13	[-0.04, 0.29]	0.02	[-0.02, 0.06]	0.13	R^2 = 0.016 95% CI[0.00, 0.07]
Fixation Duration Social	0.02	[-0.43, 0.46]	0.01	[-0.16, 0.17]	0.00	[-0.00, 0.00]	0.01	
Image-based certainty query (Enterprising) as the criterion								
(Intercept)	6.13**	[3.62, 8.64]						
Revisits Enterprising	-0.31	[-0.75, 0.12]	-0.12	[-0.28, 0.04]	0.01	[-0.02, 0.05]	-0.11	R^2 = 0.021 95% CI[0.00, 0.08]
Fixation Duration Enterprising	-0.24	[-0.63, 0.15]	-0.10	[-0.27, 0.06]	0.01	[-0.02, 0.04]	-0.09	
Image-based certainty query (Conventional) as the criterion								
(Intercept)	5.83**	[3.01, 8.66]						
Revisits Conventional	-0.04	[-0.56, 0.49]	-0.01	[-0.18, 0.15]	0.00	[-0.00, 0.00]	-0.02	R^2 = 0.010 95% CI[0.00, 0.05]
Fixation Duration Conventional	-0.28	[-0.74, 0.19]	-0.10	[-0.26, 0.07]	0.01	[-0.02, 0.04]	-0.10	

Table 5: Summary regression model 2 of H1 for the entire stimuli

Predictor	b	b 95% CI [LL, UL]	beta	beta 95% CI [LL, UL]	sr^2	sr^2 95% CI [LL, UL]	r	Fit
Image-based certainty query as the criterion								
(Intercept)	4.09**	[3.54, 4.63]						
Saccade Count	0.00	[-0.01, 0.01]	0.00	[-0.17, 0.17]	0.00	[-0.00, 0.00]	0.01	R^2 = 0.002 95% CI[0.00, 0.03]
Saccade Velocity	7.69	[-18.98, 34.35]	0.05	[-0.12, 0.22]	0.00	[-0.01, 0.02]	0.05	

3.3 Self-reported career choice certainty

The results for hypothesis H2 are presented for each RIASEC type in the following section. The AIST-based certainty query was the predictor. The criterion variable was the image-based certainty query (see Table 6). The models showed significant effects for the dimensions Realistic ($r = 0.36$, $p < 0.01$), Investigative ($r = 0.21$, $p < 0.01$) and Enterprising ($r = 0.21$, $p < 0.05$). There were only low to medium correlations between the certainty evaluation based on the images and based on the verbal test.

There was no statistical correlation for dimensions Artistic, Social, and Conventional. The results showed particularly interesting patterns, but the hypothesis H2 needs further research to clarify a valid effect.

Table 6: Summary regression models of H2 for each RIASEC type. Bold values represent significant correlations (*p < 0.05; **p < 0.01)

Predictor	*b*	*b* 95% CI [LL, UL]	*beta*	*beta* 95% CI [LL, UL]	sr^2	sr^2 95% CI [LL, UL]	*r*	Fit
Image-based certainty query (Realistic) as the criterion								
(Intercept)	3.47**	[3.06, 3.88]						R^2 = 0.127**
AIST-3-based query Realistic	**0.23****	**[0.13, 0.33]**	**0.36**	**[0.20, 0.51]**	**0.13**	**[0.04, 0.23]**	**0.36****	95% CI[0.04, 0.23]
Image-based certainty query (Investigative) as the criterion								
(Intercept)	3.64**	[3.24, 4.03]						R^2 = 0.045**
AIST-3-based query Invest.	**0.13****	**[0.03, 0.24]**	**0.21**	**[0.05, 0.37]**	**0.05**	**[0.00, 0.12]**	**0.21****	95% CI[0.00, 0.12]
Image-based certainty query (Artistic) as the criterion								
(Intercept)	4.33**	[3.96, 4.70]						R^2 = 0.003
AIST-3-based query Artistic	-0.03	[-0.12, 0.06]	-0.05	[-0.21, 0.11]	0.00	[0.00, 0.04]	-0.05	95% CI[0.00, 0.04]
Image-based certainty query (Social) as the criterion								
(Intercept)	3.94**	[3.51, 4.36]						R^2 = 0.014
AIST-3-based query Social	0.08	[-0.03, 0.19]	0.12	[-0.04, 0.28]	0.01	[0.00, 0.07]	0.12	95% CI[0.00, 0.07]
Image-based certainty query (Enterprising) as the criterion								
(Intercept)	3.71**	[3.30, 4.11]						R^2 = 0.043*
AIST-3-based query Enterpr.	**0.14***	**[0.03, 0.24]**	**0.21**	**[0.05, 0.37]**	**0.04**	**[0.00, 0.12]**	**0.21***	95% CI[0.00, 0.12]
Image-based certainty query (Conventional) as the criterion								
(Intercept)	4.20**	[3.71, 4.69]						R^2 = 0.001
AIST-3-based query Convent.	-0.02	[-0.15, 0.11]	-0.03	[-0.19, 0.14]	0.00	[0.00, 0.03]	-0.03	95% CI[0.00, 0.03]

3.4 Response time and AIST-3-based decision certainty

We used the response time as an indirect parameter of career choice certainty, because previous research has demonstrated that the response time can be a valuable parameter for decision certainty. This section details the results of hypothesis H3, with response time and AIST-3-based certainty as variables. For hypothesis H3, regression models were calculated for each RIASEC type. Additionally, a combined model over all RIASEC dimensions (further named 'Total') was run. The predictor was the response time and the criterion was the AIST-3-based certainty query. Significant correlations ($p < 0.01$) were found for Realistic ($r = -0.24$) and the combined model ($r = -0.22$) (see Table 7). The negative sign derives from the different variable scale: The higher the decision certainty was, the lower the response time. The scale in the query was the other way round. No correlations were obtained for dimensions Investigative, Artistic, Social, Enterprising, and Conventional. Hypothesis H3 can be accepted for the total response time and the decision certainty, but not for single dimensions.

Table 7: Summary regression models of H3. Bold values represent significant correlations (**p < 0.01)

Predictor	*b*	*b* 95% CI [LL, UL]	*beta*	*beta* 95% CI [LL, UL]	sr^2	sr^2 95% CI [LL, UL]	*r*	Fit
AIST-3-based certainty query (Realistic) as the criterion								
(Intercept)	5.49**	[4.51, 6.46]						R^2 = 0.060**
Response Time Realistic	**-0.89****	**[-1.47, -0.32]**	**-0.24**	**[-0.40, -0.09]**	**0.06**	**[0.01, 0.15]**	**-0.24****	95% CI[0.01, 0.15]
AIST-3-based certainty query (Investigative) as the criterion								
(Intercept)	3.83**	[2.80, 4.85]						R^2 = 0.000
Response Time Invest.	-0.04	[-0.66, 0.59]	-0.01	[-0.17, 0.15]	0.00	[0.00, 0.02]	-0.01	95% CI[0.00, 0.02]
AIST-3-based certainty query (Artistic) as the criterion								
(Intercept)	4.75**	[3.74, 5.77]						R^2 = 0.023
Response Time Artistic	-0.61	[-1.26, 0.04]	-0.15	[-0.31, 0.01]	0.02	[0.00, 0.09]	-0.15	95% CI[0.00, 0.09]
AIST-3-based certainty query (Social) as the criterion								
(Intercept)	4.15**	[3.20, 5.09]						R^2 = 0.005
Response Time Social	-0.27	[-0.87, 0.33]	-0.07	[-0.24, 0.09]	0.01	[0.00, 0.05]	-0.07	95% CI[0.00, 0.05]
AIST-3-based certainty query (Enterprising) as the criterion								
(Intercept)	4.30**	[3.28, 5.32]						R^2 = 0.007
Response Time Enterpr.	-0.34	[-0.98, 0.30]	-0.09	[-0.25, 0.08]	0.01	[0.00, 0.06]	-0.09	95% CI[0.00, 0.06]
AIST-3-based certainty query (Conventional) as the criterion								
(Intercept)	3.86**	[2.98, 4.74]						R^2 = 0.001
Response Time Convent.	-0.10	[-0.66, 0.46]	-0.03	[-0.19, 0.13]	0.00	[0.00, 0.03]	-0.03	95% CI[0.00, 0.03]
AIST-3-based certainty query (Total) as the criterion								
(Intercept)	33.03**	[25.53, 40.52]						R^2 = 0.047**
Response Time Total	**-3.03****	**[-5.24, -0.82]**	**-0.22**	**[-0.38, -0.06]**	**0.05**	**[0.00, 0.13]**	**-0.22****	95% CI[0.00, 0.13]

3.5 Response time and eye movements

We calculated two models for the hypothesis H4. The predictors for model set 1 were AOI revisits and AOI fixation duration (see Table 8). The predictors for model 2 were saccade count and saccade velocity (see Table 9). The criterion variable for both models was the response time in the AIST-3. The results of the two stimuli were cumulated for all relevant variables. Model set 1 referred to the RIASEC AOIs. Model 2 addressed the entire stimuli without AOIs. This is equal to the models of hypothesis H1.

The data provided no evidence that response time is related to eye movement behaviour. There were no significant correlations for the single RIASEC dimensions or the entire stimuli. Given the missing correlations in hypothesis H2 and H3 this is not surprisingly, because neither response time nor eye movement behaviour could be defined as indicators for vocational decision certainty.

Table 8: Summary regression model set 1 of H4 for each RIASEC type

Predictor	*b*	*b* 95% CI [LL, UL]	*beta*	*beta* 95% CI [LL, UL]	sr^2	sr^2 95% CI [LL, UL]	*r*	Fit
Response time (Realistic) as the criterion								
(Intercept)	1.60**	[1.27, 1.93]						
Revisits Realistic	0.06	[-0.11, 0.22]	0.06	[-0.11, 0.23]	0.00	[-0.02, 0.02]	0.06	R^2 = 0.004 95% CI[0.00, 0.03]
Fixation Duration Realistic	-2.95	[-70.17, 64.28]	-0.01	[-0.18, 0.16]	0.00	[-0.00, 0.00]	-0.02	
Response time (Investigative) as the criterion								
(Intercept)	1.70**	[1.39, 2.01]						
Revisits Investigative	-0.06	[-0.23, 0.11]	-0.06	[-0.22, 0.10]	0.00	[-0.02, 0.02]	-0.06	R^2 = 0.004 95% CI[0.00, 0.03]
Fixation Duration Invest.	2.84	[-72.70, 78.38]	0.01	[-0.16, 0.17]	0.00	[-0.00, 0.00]	0.00	
Response time (Artistic) as the criterion								
(Intercept)	1.59**	[1.25, 1.94]						
Revisits Artistic	0.04	[-0.14, 0.22]	0.04	[-0.13, 0.21]	0.00	[-0.01, 0.01]	0.06	R^2 = 0.014 95% CI[0.00, 0.06]
Fixation Duration Artistic	-40.46	[-105.58, 24.65]	-0.10	[-0.27, 0.06]	0.01	[-0.02, 0.04]	-0.11	
Response time (Social) as the criterion								
(Intercept)	1.52**	[1.20, 1.84]						
Revisits Social	0.06	[-0.12, 0.24]	0.06	[-0.11, 0.22]	0.00	[-0.02, 0.02]	0.06	R^2 = 0.007 95% CI[0.00, 0.04]
Fixation Duration Social	-23.57	[-93.49, 46.35]	-0.06	[-0.22, 0.11]	0.00	[-0.01, 0.02]	-0.06	
Response time (Enterprising) as the criterion								
(Intercept)	1.44**	[1.16, 1.73]						
Revisits Enterprising	0.12	[-0.05, 0.28]	0.12	[-0.05, 0.28]	0.01	[-0.02, 0.05]	0.11	R^2 = 0.014 95% CI[0.00, 0.06]
Fixation Duration Enterpr.	-18.46	[-80.96, 44.04]	-0.05	[-0.21, 0.12]	0.00	[-0.01, 0.02]	-0.04	
Response time (Conventional) as the criterion								
(Intercept)	1.49**	[1.14, 1.84]						
Revisits Conventional	0.14	[-0.05, 0.33]	0.12	[-0.04, 0.28]	0.01	[-0.02, 0.05]	0.14	R^2 = 0.038 95% CI[0.00, 0.11]
Fixation Duration Convent.	-57.68	[-125.99, 10.63]	-0.14	[-0.30, 0.03]	0.02	[-0.02, 0.06]	-0.15	

Table 9: Summary regression model 2 of H4 for the entire stimuli

Predictor	*b*	*b* 95% CI [LL, UL]	*beta*	*beta* 95% CI [LL, UL]	sr^2	sr^2 95% CI [LL, UL]	*r*	Fit
Response time (Total) as the criterion								
(Intercept)	5.62**	[5.34, 5.90]						
Saccade Count	0.00	[-0.00, 0.00]	0.02	[-0.15, 0.19]	0.00	[-0.00, 0.01]	0.03	R^2 = 0.002 95% CI[0.00, 0.02]
Saccade Velocity	3.04	[-10.51, 16.58]	0.04	[-0.13, 0.21]	0.00	[-0.01, 0.01]	0.04	

4 Discussion

Normally, career choice is measured with scale-based questionnaires. Despite decades of working with this method, the results are not without controversy. There can be biases through an insufficient attention span, socially desirable statements, or extreme response styles. This study used quantitative techniques to analyse career choice certainty and vocational interest in a new way: with the help of eye tracking parameters and response time. Therefore, we created two pictorial stimuli which illustrate professions according to John L. Holland's RIASEC model. An eye tracker recorded the fixation and saccadic metrics. The participants were forced to make a choice which profession they liked the most and how certain they were about this choice. We correlated eye movement data with data from certainty statements in an image-based certainty query and data from a query after a standardised vocational interest test (AIST-3).

4.1 Eye movements and vocational interest

The experimental hypothesis H5 provides convincing evidence of a link between the strength of vocational interest and dwell time as well as fixation count. Correlations ranging from $0.32 \leq r \leq 0.63$ were obtained for dwell time, and $0.35 \leq r \leq 0.59$ for fixation count, across all RIASEC dimensions. The findings of the experimental hypothesis H5 provide further support for the relationship between personality traits (such as vocational interest) and eye movement behaviour (Berkovsky et al., 2019; Hoppe et al., 2018; Risko et al., 2012). In addition to the present findings, two other studies have indicated that there is a stable significant effect between vocational interests and eye movements (see Table 3). The relationship remained stable and improved with a higher number of occupations presented and a larger sample size. Furthermore, the effect was sustained even if the participants' interest distribution was different. For example, the most preferred dimensions were Enterprising in the study of Malitzke et al. (2025a), Investigative in the study of Malitzke et al. (2025b) and Conventional in the present study. These findings provide evidence of a stable association between eye movement behaviour and vocational interest, regardless of the way vocational interest is assessed (with a scale-based self-report or an image rating). Vocational interest influences visual perception and, therefore, how external information is cognitively processed. The general picture emerging from the analysis and literature review is that vocational behaviour in terms of interest, performance and expertise level can be read from eye movement behaviour (Aljehane et al., 2023; Francuz et al., 2018; Reingold & Sheridan, 2011). The way we process visual stimuli reflects our individual attitudes: who we are, how we feel, and what we like. Involuntary and spontaneous eye movements in a visual search task can be used to get valid results without bias through language dependency, extreme response styles, or social desirability. Therefore, eye tracking tests are a suitable instrument to complement the current career counselling methods.

4.2 Eye movements and career choice certainty

Contrary to our expectations, we found no link between eye movements and the career choice certainty–neither with self-reported career decision certainty nor with response time as indirect variables of the choice certainty. For the latter, the finding is less surprising if we consider the lack of correlations between AIST-3 response time and self-reported decision certainty (hypothesis H3). This means that there is no correlation between response time and eye movement behaviour either. For this study, fixation metrics, saccadic parameters, and AOI revisits were not suitable to measure the career choice certainty of adolescents between 16 and 19 years of age. Eye tracking metrics like pupil diameter are maybe valid for adults (Brunyé & Gardony, 2017) and people who are already working in a job, but we found no evidence for adolescents in the career orientation phase. Savazzi et al. (2014) revealed some interesting findings in adolescents' responses to art and images. The authors are convinced that adolescents cannot be compared to adults regarding their visual interest and eye movement behaviour. The influence of top-down processes on perception develops over time in adolescence. Their findings revealed that the number of AOIs visited and the dwell time of adolescents differed from older persons. This could be a possible reason for the missing significant correlations between eye movements and the career choice certainty. The perception of the adolescents could be influenced by bottom-up factors like colours, shape, orientation or the complexity of the stimulus which in turn biased the certainty rating.

Search and choice behaviour are often parts of the same (research) task, but they usually have been addressed in separate streams of research and rarely evaluated together. Response time, as an endpoint measure, is a widely used method in decision-making research (Wolfe, 2018). Endpoint measures are valuable for predicting final choices, but cannot fully explain underlying cognitive processes or cognitive mechanisms of interest (Treisman & Gelade, 1980; Zelinsky, 2008). Whereas eye movements can reflect perceptual, cognitive, and evaluative processes (Findlay & Gilchrist, 1998). In this study, response time and eye movements relate to the same research question: How certain are you about your career choice. The different stimuli used to evaluate the parameters–a complex image for eye movements and a verbal test for response time–did not lead to the same expressions of decision certainty. This raises the question: What did these parameter measure? Which of them analysed the choice certainty? Or maybe none of them? The eye tracking parameters can be biased through the complexity of the images, bottom-up processes, and not fully developed top-down processing (as mentioned above). The response time can be biased through a lack of motivation while answering the 60 items and maybe technical problems due to the unstable WiFi. Future studies should address one of the parameters (eye movements or response time) and evaluate it in a simpler way, than we did, because we are still convinced of a relevant connection.

The last point that should be mentioned is the missing evidence for the gaze cascade effect (Shimojo et al., 2003) for adolescents vocational preferences. We assumed that participants, who were certain about their career choice, would focus on their preferred AOI more often, would have shorter saccades, and would have a lower number of fixations. But the results did not confirm the assumptions. The results of the self-reported choice certainty exhibit a high certainty of career choice. The eye movements could not verify this judgment. Participants did not look more often to their self-reported career preference. Perhaps the stimuli strength was too low so that the perceptual decision certainty was also weak and the results were distorted by noise. Furthermore, studies on the gaze bias effect used simple stimuli and free viewing tasks (Saito et al., 2017). Our study is more complex with the detailed pictures. Future studies will have to isolate biases (for example with a laboratory setting and simpler choice task) to review our findings.

4.3 Response time and career choice certainty

The second main objective of this study was to validate previous findings on the relationship between self-reported choice certainty and response time (hypothesis H3). We wanted to clarify the influence of choice certainty on response time. Several studies have shown that reaction time and response time are directly linked to decision certainty. For example, a long response time is associated with low decision certainty (Henninger & Plieninger, 2021; Kiani et al., 2014) . We adapted this hypothesis and tested it with certainty in career decisions. The results yielded partially evidence of a relationship between response time and career choice certainty. We ran regression models for all six RIASEC dimensions and one cumulated model over all dimensions. The model for dimension Realistic was the only one that obtained significant correlations ($r = -0.24$; $p < 0.01$). Furthermore, the combined model also revealed a significant effect ($r = -0.22$; $p < 0.01$). Our findings are consistent with the work of

Kiani et al. (2014), who found an inverse correlation between certainty and reaction time. The five remaining RIASEC dimensions Investigative, Artistic, Social, Enterprising, and Conventional did not exhibit any significant effect. Previous studies also mentioned that response time is a difficult predictor due to high bias through noise. They suggest mixed effect models (Lo & Andrews, 2015), for better results. We tried this approach with our data, but we found no difference to the linear regression models.

What are the reasons for this results that are not fully in line with previous literature? The inconsistency may be due to the six sublevels, which made the analysis complex. The data was not normally distributed. The response time data indicates a Weibull distribution similar to previous studies (Gvozdenko, 2010; Tatsuoka & Tatsuoka, 1978). Partially the data was extremely right-skewed (for example in dimension Artistic and Social). The AIST-3 certainty query data was left-skewed, which is a common distribution for certainty ratings. The missing correlations might be explained by the fact that not all participants, who answered quickly, were certain about their career choice. Some might have been biased by extreme response styles or a lack of motivation. The AIST-3 certainty query was assigned at the end of the data collection, and the adolescents had already gone through a 20-minutes data collection procedure. Sometimes, the study leader had to explain the query task twice because the participants misunderstood the task in the first attempt. This bias may have been balanced out in the combined model, so that there is a correlation between the response time and the certainty statement.

4.4 Image-based und AIST-3-based certainty tests

Our findings provide preliminary evidence that vocational decision certainty can be assessed using either an image-based or text-based query approach (hypothesis H2).

Specifically, we observed low but statistically significant correlations for three out of the six RIASEC dimensions. The responses in the Realistic, Investigative and Enterprising dimensions showed correlations ranging from $0.21 \leq r \leq 0.36$. Both queries used a 5-point Likert scale. The image-based assessment evaluated the certainty based on participants' perceptions of job-related images, whereas the text-based assessment measured the certainty according to the answers in a standardised vocational interest inventory. The self-reported certainty can be valid for both types of tests; however, future research should address potential sources of biases. In the present study, the absence of significant correlations in some dimensions may result from misunderstandings of the rating scales or the phrasing of the questions. The study leader noted that some participants required further explanation of the tasks, which may have introduced biases into the results. Another potential limitation could be the division into six distinct RIASEC dimensions, which may have been overly granular. A more aggregated model, assessing overall career choice certainty rather than individual RIASEC dimensions, might be more effective.

The findings reveal a high impact of the way, how tasks are defined. The formulation of the questions and the selection of the stimulus influence the certainty ratings. The visual query combines two cognitive processes: visual perception and decision-making. The verbal query addresses only decision-making without a prior external stimulus. This difference could cause the missing correlations between the image-based and the AIST-3-based certainty test. In the visual test, factors like curiosity, enjoyment or design preferences might lead to other certainty ratings (Berlyne, 1966; Hidi & Renninger, 2006). Despite these limitations, our findings suggest that a perceptual approach holds promise for assessing vocational interests. With refinements in methodology and measurement precision, eye tracking could emerge as an alternative to traditional paper-and-pencil assessments and scale-based self-reports.

5 Conclusion

The primary objective of this study was to analyse the extent to which eye movement behaviour and response time can act as effective parameters for evaluating vocational interest. The relationship between these variables is more complex than initially anticipated, involving intricate interactions between bottom-up and top-down processes that direct eye movements and influence response behaviour. The overall finding suggest that eye tracking is a valuable tool for examining the strength of vocational interest. However, contrary to our expectations, eye tracking did not prove effective in determining career choice certainty. Instead, response time emerged as a more reliable parameter for analysing choice certainty. For accurate results, it is crucial that the technical conditions are robust. It is important to recognise that response behaviour during adolescence is still maturing and may be affected by external factors that could skew the findings. For this study, the RIASEC model was chosen as the theoretical basis. Holland's theory once again proved its effectiveness, as it was beneficial for the meaningful definition of the image AOIs. Furthermore, the framework structured the image-based evaluation and made the comparisons with the standardised AIST-3 questionnaire valuable. Our results indicate that choice certainty can be assessed using both image-based stimuli as well as traditional self-report methods. Future research should investigate the conditions under which perceptual decision-making, in the context of vocational interest, can serve as a reliable and valid technique. On the practical side, a further development of the method could be used as a supplementary tool in career counselling. The gamified approach of the assessment of vocational interest is especially for adolescents a door opener on the subject of career orientation.

3 General Discussion

The following chapter critically examines the main findings of the three empirical studies, their implications for perceptual and interest psychology, and the strengths and limitations of the research design. It also outlines unresolved questions and directions for future research.

3.1 Summary and discussion of findings

The first section provides an overview of the findings concerning the strength of vocational interest and the career choice certainty. To this end, the results of the three empirical studies are summarised. In total, 316 adolescents (female: 190; male: 126) participated in all studies. The average age was 16.97 years. The studies were carried out from February 2002 to April 2024 in eleven schools, at three career fairs and during four career events (such as ‘Jugend forscht’) in Germany. The results derived from eye tracking analysis, AIST-3 questionnaire, occupational-related image evaluation and response time measurement are discussed further.

3.1.1 Eye movement behaviour

All three studies demonstrated a robust association between eye movements and the strength of vocational interest. The specific parameters are discussed in the following section. In contrast, career decision certainty did not show a straightforward correlation with eye movement patterns. The methodological and interpretive challenges encountered in this context are addressed in the subsequent discussion.

Strength of vocational interest

Designing a test setup capable of producing reliable results presented a methodological challenge. Critical factors, such as task wording and stimulus presentation time, were systematically evaluated through pre-tests, with optimal parameters implemented in the final experimental procedure.

All three studies revealed that dwell time and fixation count are robust predictors of the strength of vocational interest. In Study 1, significant effects were observed in five of the six RIASEC dimensions, with the Conventional dimension being the only exception. However, with improvements in the testing procedure, an additional picture for dimension Conventional and an increased number of AOIs in Studies 2 and 3, significant correlations were identified across all six RIASEC dimensions. The correlations, analysed using linear regression models, ranged from moderate to high ($0.29 < r < 0.67$), within a significance range of 0.01 to 0.05. The eye tracking metrics, categorised according to the RIASEC dimensions, exhibited internal consistency values ranging from 0.00 to 0.74 for dwell time and from 0.17 to 0.71 for fixation count (see Appendix A). For comparison, the internal consistency of the NVIS ranges between 0.80 and 0.90 (Weißmann et al., 2022). This variability can be attributed to the considerable heterogeneity of the professions selected for the image stimuli. To ensure a broad representation of potential vocational interests, participants were exposed to a diverse array of professions, increasing the likelihood that they would encounter at least one interesting occupation. Consequently, professions within the same RIASEC category were intentionally chosen to be dissimilar, rather than closely related, to maintain this diversity.

To test the prognostic validity of fixation count and dwell time, a 10-fold cross validation was carried out in Study 2. The R^2 ranged from 0.24 (SD = 0.19) to 0.51 (SD = 0.23) in models with dwell time and entry time as predictors. In models with fixation count as predictor the R^2 ranged from 0.19 (SD = 0.21) to 0.47 (SD = 0.23). All models exhibited the hightes perfomance for dimension Investigative and the lowest for Enterprising. The cross-validation analysis revealed differential prognostic validity across the RIASEC dimensions. While some visual stimuli already demonstrate strong predictive utility, others lack sufficient specificity and remain too ambiguous to yield reliable outcomes. These discrepancies highlight the need for further refinement in stimulus design and underscore the importance of systematically evaluating the test's psychometric properties in future iterations.

A third eye tracking parameter–time to first fixation on an AOI–was examined but did not yield significant effects. Although participants began the visual search task from the same starting point, the randomised placement of the AOIs across trials disrupted any systematic relationship. As a result, the time taken to first fixate on an object or scene cannot predict the strength of vocational interest. Instead, this parameter is largely influenced by various other variables like the random spatial positioning of the AOIs and individual's visual search patterns.

The unique aspect of assessing vocational interest through eye movements lies in the intuitive visual search process, wherein individuals make conscious occupational choices while viewing complex images. Recent research suggests that eye movement behaviour occurs in two distinct phases. The initial phase involves an automatic information search characterised by brief fixations as participants scan the stimuli. The second phase is associated with deliberate decision-making, during which fixation durations exceed 500 milliseconds (Horstmann et al., 2009; Velichkovsky, 1999). Findings from the three empirical studies in this thesis revealed a mean fixation duration of 416.16 ms (SD = 161.79; MIN = 122.4 ms; MAX = 2804.4 ms). In the doctoral studies the two distinctive phases could not be separated from each other as accurately as in the studies of Horstmann et al. (2009) and Velichkovsky (1999). When calculating the mean fixation duration, the measures between the first and last fixation within a relevant AOI was taken into account. The results provide strong evidence that participants engaged in rapid and intuitive decision-making regarding their preferred occupations. The observed fixation durations suggest that participants were not merely passively viewing the images without cognitive engagement; rather, they were actively processing visual information. At the same time, the results indicate that participants did not engage in excessive deliberation but approached the task with an appropriate level of attentional focus and seriousness. Example of the viewing behaviour can be found in Appendix C – Scan path examples on page 194.

To assess the strength of vocational interests, analysing eye movement behaviour while observers view occupational images served as a reliable methodological approach. The findings align with previous research on general and situational interest (Berlyne, 1971; Engelke & Le Callet, 2015; Langsdorf et al., 1983; Risko et al., 2012; Silvia, 2005). In the context of visual decision-making, the gaze bias effect suggests that observers tend to fixate longer on stimuli they find interesting, even in the presence of competing distractors (Saito et al., 2017). The present thesis confirms this effect by demonstrating a strong correlation between dwell time/fixation count and vocational interest. Specifically, adolescents exhibited prolonged visual attention toward stimuli representing their preferred career choices.

Career choice certainty

Besides dwell time, fixation count and time to first fixation for assessing the strength of vocational interest, saccadic metrics and AOI revisits were analysed for the career choice certainty in Study 2 and Study 3. In contrast to the stable correlation patterns of the strength of vocational interest, there were less significant effects for eye movements and career choice certainty. The data analysis was carried out to verify previous findings of Brunyé and Gardony (2017), Orquin and Mueller Loose (2013), and Spering (2022) and apply them on the specific topic of vocational interest, significant correlations were sporadic and weak. The results of Study 2 exhibited the only relevant relationship between saccade count and response time ($r = 0.27$; $p < 0.05$). Response time was used as an endpoint measure for career choice certainty. The saccade count served as a direct and real-time parameter to analyse the career choice certainty. Additionally, in Study 3 the eye movements were correlated to self-reported choice certainty. These models revealed no significant correlations.

Now the question arises, why previous findings could not be verified? One reason is the difference of the stimuli design. Previous studies focussed merely on the choice between two objects (for example convenience products or appealing forms). The present studies have complex and detailed image scenes with a vast number of objects. Several distractors can deviate participants' attention to irrelevant objects or scenes. Additionally, the eye movement metrics did not correlate with the imaged-based and the AIST-based certainty query. But the two queries correlated slightly with each other (see Section 3.1.3, page 137). One might say, participants were unsettled by the question about the certainty of their decision. Many adolescents between the age of 16 and 19 are not yet sure what career they want to pursue. When asked about this, they may give false or inconsistent answers in order to avoid admitting their uncertainty.

In summary, dwell time and fixation count are recommended as reliable parameters for assessing the strength of vocational interests. By contrast, eye tracking is not yet considered a suitable method for analysing career choice certainty.

3.1.2 Response time

In addition to the eye tracking parameters, a further behaviour-based measure was incorporated to assess the career choice certainty: the item response time in a standardised vocational interest test (AIST-3). Prior research has established a relationship between decision-making certainty and response latency in scaled assessments (Börger, 2016; Gvozdenko, 2010; Kiani et al., 2014; Tracey & Tao, 2018). Response time is widely regarded as an indicator of cognitive processing styles and personality traits, such as decisiveness and variations in thinking speed (Naemi et al., 2009).

Studies 2 and 3 investigated the potential of response time as an indirect measure of career choice certainty. In Study 2, response time was employed as a criterion for decision certainty and was correlated with saccadic eye movements, which has been proposed in the literature as an indicator of decision reliability (Brunyé & Gardony, 2017; Orquin & Mueller Loose, 2013). Specifically, saccade count and saccade duration were analysed using linear regression models to determine significant effects. The findings revealed a low but statistically significant correlation between saccade count and response time ($r = 0.27$; $p < 0.05$), whereas saccade duration did not exhibit relevant correlations with response time. At this stage of the doctoral research, the suitability of response time as a robust measure of decision reliability remained inconclusive. However, these initial findings provided a foundation for further empirical investigation in a third study.

Study 3 focused on the certainty of vocational interests. The primary objective was to assess whether eye tracking metrics serve as meaningful parameters for career decision certainty and to examine their correlations with response time. This study aimed to identify eye tracking variables that could function as alternative measures of vocational interest certainty, beyond response time and self-reported scale-based assessments. A regression model with the total response time of the AIST-3 items and the AIST-3-based certainty rating (across all RIASEC dimensions) as variables yielded a weak negative correlation ($r = -0.22$; $p < 0.01$), indicating that higher career choice certainty was associated with shorter response time. This effect was also observed for the RIASEC dimension Realistic ($r = -0.24$; $p < 0.01$), whereas the remaining five RIASEC dimensions did not exhibit significant correlations. These findings suggest that analysing response time at the level of individual RIASEC dimensions may be too granular, as various confounding factors likely influence response latency (a detailed discussion of potential biases follows in the subsequent sections). However, total response time appears to be a viable measure of vocational interest certainty.

Moreover, personality traits play a significant role in decision latency, shaping both vocational interests and career indecision (Burns et al., 2013). Empirical research has demonstrated differences in search behaviour between introverts and extroverts. Sen and Goel (1981) argued that introverts tend to perform more effectively in visual search tasks compared to extroverts. This suggests that vocational interest alone may not be sufficient to predict decision certainty, as personality-driven cognitive processing differences could also play a role. Another potential explanation for the lack of a significant relationship between response time and eye movement behaviour is the assumed linear correlation between these variables. Consistent with findings from previous response time studies, the data in the present doctoral research followed a Weibull distribution rather than a normal distribution (Gvozdenko, 2010; Tatsuoka & Tatsuoka, 1978). Similarly, the eye tracking data did not exhibit a normal distribution. These results indicate that response time and eye movements do not share a straightforward linear relationship. However, the possibility of a non-linear association between these parameters remains. Further research is necessary to enhance the reliability and validity of response time in the assessment of career choice certainty.

3.1.3 Occupation-related image evaluation

To evaluate the strength of vocational interests and the career choice certainty, two different queries were conducted across Study 1, Study 2, and Study 3. All data was analysed by using simple or multilevel linear regression models. The first query, designed to assess the strength of vocational interests, was implemented in all three studies. Participants rated their interest in the depicted professions, corresponding to the RIASEC AOIs. Regression models were employed, incorporating AIST-3 responses and eye tracking parameters as variables. The analyses yielded significant correlations ($p < 0.01$) in all RIASEC dimensions, except in Study 1, where the Conventional type did not exhibit statistically significant effects. The observed correlations were strong across all RIASEC dimensions. The mean values ranged from $r = 0.53$ for dwell time and $r = 0.48$ for fixation count as predictors and the image query as criterion. Findings indicated that higher occupational ratings were associated with increased fixation duration and frequency on the corresponding AOI. Furthermore, the image query demonstrated a strong positive correlation with participants' AIST-3 responses ($r = 0.56$).

The studies utilised data from two stimuli, each depicting six distinct professions, resulting in a total of two professions per RIASEC dimension. The internal consistency (pooled analysis) of the image query scores, as measured by Cronbach’s alpha across all three studies, ranged from 0.33 (Enterprising) to 0.63 (Investigative) (see Appendix A). Among the six dimensions, only the Realistic and Investigative categories demonstrated acceptable reliability. A potential explanation for this variation in reliability is the degree of similarity between the professions represented within each dimension. For instance, both images associated with the Investigative dimension depict laboratory settings, contributing to a higher internal consistency. In contrast, dimensions with lower reliability scores, such as Enterprising, feature professions with substantial contextual differences. Specifically, one Enterprising image illustrates an electronics store, while the other portrays a business meeting, potentially leading to greater variability in participants’ responses.

The overall results support the effectiveness of occupation-related visual assessments for evaluating the strength of vocational interests. This conclusion aligns with previous research, which has extensively validated image-based vocational interest tests.

Due to the limited number of presented professions, the reliability remains low. A larger selection of occupational representations may improve the reliability. The findings from the doctoral thesis further suggest that the image type illustration is particularly appealing to adolescents. Notably, during data collection, many adolescents expressed enjoyment in engaging with the pictorial stimuli and reported positive experiences while completing the visual vocational interest assessment.

In summary, the career choice certainty was assessed using four distinct parameters:

1. response time,
2. eye movement behaviour,
3. image-related certainty query,
4. and AIST-3-related certainty query.

The first two parameters were already discussed, while the latter two are reviewed in the following sections. The assessment of career choice certainty via image-based and AIST-3-based querying was conducted exclusively in Study 3. Regression analyses did not exhibit the same stable pattern of significant correlations as those assessed for the strength of vocational interest. Specifically, only three of the six RIASEC dimensions demonstrated significant associations between self-reported certainty in the AIST-3-based and image-based queries: Realistic ($r = 0.36$; $p < 0.01$), Investigative ($r = 0.21$; $p < 0.01$), and Enterprising ($r = 0.21$; $p < 0.05$). Although both queries employed a scale-based rating system, they did not capture career choice certainty in an identical manner. The image-based query referenced participants' certainty according to their previously indicated interest levels in a specific AOI, whereas the AIST-3-based query referred to participants' certainty according to their responses in the standardised AIST-3.

A potential explanation for the missing correlations is the duration of the testing procedure. The image-based query was administered approximately three minutes after the onset of the experiment, whereas the AIST-3-based query was conducted near the conclusion of the procedure, approximately 20 minutes post-initiation. Participants' motivation and engagement decreased by the time they reached the final query, potentially leading to less accurate responses. Additionally, fatigue or a desire to expedite the completion of the assessment may have influenced their responses during the later stages of data collection.

To evaluate this hypothetical reason, the data of the AIST-3-based certainty query and the AIST-3 scores were tested with linear regression models. This was done in order to examine the data with regard to randomness. If the participants were unmotivated and unfocussed, there would be no significant effect. However, significant correlations between $|0.21| < r < |0.28|$ ($0.01 < p < 0.05$) were observed across all RIASEC dimensions except for the Investigative dimension. These findings indicate that the AIST-3-based certainty query did not capture data entirely out of context. However, various factors likely influenced the results. Notably, an interesting pattern emerged in these regression models. Specifically, for the Realistic and Conventional dimensions, a negative correlation was observed, suggesting that higher AIST-3 scores were associated with lower certainty ratings and vice versa. This implies that the less interesting a RIASEC dimension was, the greater the participants' certainty in their aversion to it. Furthermore, the more uncertain adolescents were about their vocational interests, the more likely they were to report high interest in the corresponding RIASEC type. As a result, participants appeared to exhibit a general uncertainty regarding their responses, which may have contributed to the lack of correlations between the different certainty measures.

This issue of uncertainty in self-reported data has been discussed in prior research. Wilson and Gilbert (2003) argued that individuals struggle to accurately predict their future reactions and emotions. Given that career certainty involves forecasting future satisfaction with occupational choices, expressing a clear and confident response is inherently difficult for individuals. Additionally, research has demonstrated that hypothetical decision-making often diverges from actual behaviour. For instance, Holt and Laury (2002) found that while participants displayed risk-averse behaviour when dealing with large sums of money in a controlled experiment, they exhibited greater risk-taking tendencies in real-world financial decisions when managing substantial assets. A similar effect may have influenced the present study. Some participants may have initially felt confident in their preferred RIASEC dimension when completing the AIST-3 assessment. However, when subsequently asked to rate their certainty, they may have experienced doubts as they were prompted to reassess their initial choices.

The preceding discussion has highlighted that career decision-making is a highly complex process influenced by multiple factors. To systematically assess potential biases in future studies, summarising these influencing variables is essential. The integrative model of career indecision proposed by Xu and Bhang (2019) provides a suitable framework for this purpose. This model identifies five key factors affecting decision-making:

1. negative affectivity
2. choice and commitment anxiety
3. information needs
4. lack of readiness,
5. and interpersonal conflicts.

The first factor is particularly relevant in the context of extreme response styles in self-reported career choice. The second factor primarily influences response time and self-reports, potentially leading to socially desirable occupational preferences. The third factor contributes to career decision-making anxiety, as the extent of information required to make an informed choice plays a critical role in the decision process. The fourth factor encapsulates uncertainty in career decision-making. The fifth factor pertains to the distinction between intuitive and deliberate decision-making depending on the way vocational interest is assessed. Given the multifaceted nature of career decision-making, the inability of both the image-based certainty query and the single-item AIST-3 certainty query to fully capture this complexity is unsurprising.

The key findings of this thesis are summarised as follows: The strength of vocational interest can be assessed using dwell time, fixation count, and an image-based evaluation. The longer participants look at a certain profession, the more interested they are in the occupational activity. The accuracy of vocational interest predictions increases with the number of stimuli presented. The career choice certainty is a complex phenomenon that can partially be evaluated through saccade count, response time and scale-based self-reports. A cumulative analytical approach is more suitable than a granular examination of individual RIASEC dimensions, as it provides a more comprehensive assessment. Furthermore, potential biases should be taken into account, like extreme response styles, interpersonal conflicts, problems with the technical equipment (internet stability) or extended testing durations.

3.2 Theoretical and practical implications

This section interprets the empirical findings in a theoretical and practical context. The theoretical part highlights the underlying cognitive concepts of information processing and visual search behaviour as well as the relevance to the RIASEC framework. The practical part recommends eye tracking as a diagnostic method to assess the strength of vocational interest.

Theoretical implications

While numerous scholars have previously examined the relationship between situational interest and eye movement behaviour, there is a general consensus on the strong correlation between these variables (Langsdorf et al., 1983; Risko et al., 2012; Soleymani & Mortillaro, 2018). However, no prior research has explored the connection between individual interest as a personality trait and eye movements in the manner presented in this study. Participants were required to select their preferred profession from six simultaneously displayed occupations in a complex image. The significant correlations demonstrate that this forced-choice task of visual exploration is a viable and effective alternative to the dual-choice tasks employed in previous studies.

Findings indicate that participants exhibited sustained visual attention toward the RIASEC AOIs that were most relevant to their individual preferences. The general introduction emphasised the distinction between eye movements and visual attention, a critical issue in eye tracking research. Eye tracking allows for the identification of gaze direction but does not inherently reveal the reasons for this. Through the present study design, these aspects were integrated, enabling a more comprehensive understanding of eye movements, visual search behaviour and interest trait. The standardised vocational interest test validated the congruence between the most frequently observed RIASEC AOIs and participants' preferred professions. The observation time was sufficient for the participants to visually process the image stimuli and make a decision. This supports the following cognitive relation: the direction of the gaze indicates the allocation of overt visual attention, which in turn reflects an individual's vocational interest within the corresponding RIASEC dimension. In the present use case eye movements and visual attention correspond with each other and are guided by individual interest traits.

In visual perception, both top-down and bottom-up processes significantly influence attention allocation. A key challenge in the present stimulus design was minimising bottom-up influences to ensure that participants' eyes were directed primarily by top-down control through the search task. To assess the impact of bottom-up features, salience maps were generated in MATLAB using the Itti and Koch algorithm (Itti et al., 1998). A comparative analysis of the salience maps and participants' scan paths indicated a minimal effect of bottom-up features on visual search behaviour. The potential for bias was rated as low for each image stimulus. These findings align with previous research, demonstrating that visual search in a forced-choice task is predominantly guided by top-down control, whereas bottom-up influences and salience play a more substantial role in free exploration tasks that lack a defined objective (Polatsek et al., 2018). The top-down control was influenced by interindividual differences, including:

1. vocational interests,
2. affective responses to the depicted occupational activities,
3. prior knowledge of professions (e.g., internships or parental careers),
4. and self-identification with the portrayed characters.

The present study is grounded in Holland's RIASEC theory, a well-established framework in career research. Its structured categorisation of professions and detailed dimension descriptions facilitated the stimulus design. The findings support Holland's assertion that each RIASEC type processes (visual) information differently (Holland, 1997). Moreover, they demonstrated the model's applicability beyond self-report measures to behaviour-based assessments. The six-category structure allowed for a clear yet detailed stimulus presentation using a 3×2 grid for AOI positioning, ensuring multiple decision options without overwhelming the participants.

In addition to Holland's hexagonal model, hierarchical representations by Gati and Rounds suggest that certain RIASEC types, such as Realistic–Investigative and Enterprising–Conventional, cluster together (see Figure 2, page 22). Prior research (Gati, 1979; Nagy et al., 2010; Rounds & Tracey, 1996) highlights the Enterprising–Conventional pairing, and the present findings provide further support. Internal consistency analyses of the eye tracking data and image-based query values for these types revealed moderate to high consistency (0.58–0.69; see Appendix A, page 192). In Study 1, Conventional did not show significant correlations, whereas Enterprising displayed strong associations. This was possibly due to participants, which were actually interested in the Conventional type, but favoured the Enterprising images over Conventional, and thereby biased the results. The similarity of Enterprising and Conventional AOIs, both depicting office scenes (in stimulus 1 and 2), suggests that visual overlaps in RIASEC dimensions may exist, questioning the strict separation of the six types in a hexagonal model without hierarchical structure.

The studies 2 and 3 of this dissertation did not fully confirm previous findings regarding the career choice certainty. Neither response time nor eye tracking parameters, such as saccadic behaviour, demonstrated consistent relationships with appropriate correlations. As mentioned earlier in Section 1.2.3, research has primarily focused on situational interest and decision-making in non-consequential contexts. This raises a critical question: To what extent can intuitive, behaviour-based methods effectively assess complex cognitive processes such as self-reflection on career decisions? Alternatively, might a more deliberate methodological approach be better suited for such evaluations? These research questions offer great potential for further research.

Practical implications

From a practical perspective, assessing vocational interests through eye movements holds significant potential. This method aligns with existing perception-based career tests while introducing innovations in accuracy, engagement, and ease of use. It retains the advantages of visual career assessments over traditional scale-based tests, including language independence, an intuitive test approach, rapid administration, and reduced susceptibility to socially desirable responses. Moreover, it provides quantitative data beyond self-reported ratings, enabling a more precise prediction of preferred RIASEC types–an aspect lacking in conventional visual career tests, which typically rely on rating scales for occupational images (e.g., R-FVII-R, F-I-T, or NVIS with smiley ratings). Instead, the proposed method prioritises RIASEC preferences based on dwell time and fixation count within specific AOIs, eliminating the need for subjective and self-reflective ratings.

During the data collection phase of Study 1 and 2, the eye tracking test was integrated into a comprehensive career counselling framework. At participating schools, the test was conducted first, followed by a feedback session where the adolescents received their results from the test administrator. These results were used in career counselling sessions with advisors from the German ‘Agentur für Arbeit’. In practical implementation, the eye tracking test is particularly suited as an initial step in the career orientation. Its gamified approach effectively engages both adolescents and younger individuals, fostering interest in career exploration. The test is particularly beneficial for individuals uncertain about their career choices, as it intuitively captures both conscious and subconscious vocational interests. It provides a holistic and objective assessment of an individual's true vocational interest.

The eye tracking test was marketed under the working title *JobVision* to enhance its appeal among career counsellors, educators, career fair organisers, and adolescents. Instead of presenting the study as a scientific investigation for a doctoral dissertation, schools received a visually engaging flyer under the JobVision branding (see Appendix E – Flyer JobVision, page 198). This strategy proved effective, as the name gained recognition over the three-year data collection period through social media, newspaper coverage, and Aalen University's public relations efforts. Consequently, from Study 2 onwards, schools and career fairs no longer needed to be actively recruited; instead, they independently approached JobVision to request participation.

To effectively and efficiently integrate the eye tracking test into career counselling, one key requirement must be met: career counsellors must be able to conduct the test independently without expert knowledge on eye tracking and visual perception. The current test setup is designed for empirical research and lacks intuitive user-friendliness, making it impractical for the use by non-experts. Eye tracking data is collected using a professional eye tracking system, with data analysis conducted manually through data export and data processing in the statistical software R. For commercial applications, the test must be embedded into a user-friendly interface to ensure accessibility for non-experts. The goal is to enable automated processing, where eye movement recordings serve as input, and the system generates a three-letter RIASEC code as output without requiring expert intervention.

To establish JobVision as a reliable diagnostic assessment, several psychometric quality criteria must be systematically evaluated. The present thesis focused on cross-sectional studies to determine whether vocational interests can be assessed through eye movements, occupational evaluations, and response time. However, a longitudinal analysis of the stability of significant correlation patterns has yet to be conducted. Reliability and validity must be examined in a replication sample. For instance, test-retest reliability should be assessed through longitudinal studies tracking adolescents during their entire career orientation phase or by comparing their later occupational choices with initial test results to establish predictive validity. Additionally, validity should be further investigated through qualitative item analysis to assess the discriminatory power of the images. Discriminant validity must also be tested by comparing

JobVision results with other image-based vocational assessments, such as the F-I-T. Finally, differential validity should be analysed across age, gender, and cultural background to ensure an internationally applicable and diverse test instrument. These considerations highlight numerous avenues for future research to further validate the effectiveness of perception-based vocational interest assessments (see Section 3.5, page 156).

In conclusion, the findings of this thesis offer valuable insights into the measurement of vocational interests from both theoretical and practical perspectives. The observed relationship between vocational interest and eye movements aligns with previous research on situational and general interest, as well as the gaze bias effect. However, the results regarding the career choice certainty did not confirm prior findings, highlighting a promising area for future research to further investigate behaviour-based interest assessment. From a practical standpoint, the findings hold significant implications for career counselling. The test procedure has reached a stage where a scientifically grounded assessment framework can be developed, providing a strong foundation for future user-friendly applications in vocational diagnostics.

3.3 Strengths

The primary research contribution of this thesis is its holistic approach to assessing vocational interests. Analysing vocational interests through eye tracking methodology presents several advantages over traditional scale-based inventories. These include enhanced inclusivity through a reading-independent procedure, significantly reduced administration time within a few minutes, minimised social desirability bias due to the involuntary nature of visual attention, and the elimination of extreme response patterns that can influence the data quality. For decades, vocational interests have been predominantly measured using scale-based self-reports, initially in paper-and-pencil format and later as online self-assessments. Despite this transition, the underlying methodology has remained largely unchanged.

Given the rapid advancements in media usage and technological innovation, assessment tools must evolve to align with the adolescents' digital environment. Eye tracking technology offers a promising alternative, providing increasingly precise and meaningful insights in an era of information overload. By capturing involuntary visual behaviour, eye tracking can offer a more objective representation of cognitive and affective processes, revealing individuals' underlying vocational preferences. This aligns with research in embodied cognition, which emphasises the intrinsic connection between mind and body (Fang & Zhu, 2023; Varela et al., 2016). As mental states can be inferred through physiological responses, eye tracking presents a novel opportunity for behaviour-based career interest assessment. Rather than resisting such methodological advancements, they should be embraced to enhance vocational diagnostics. The following paragraphs discuss the advantages of this approach in greater detail.

Scale-based self-reports inherently exclude certain adolescent target groups, as they are designed for individuals with strong language skills, stable mental health, and an intrinsic motivation to perform the test. However, this does not reflect the diversity of real-world populations. For instance, an estimated 3–8% of the German population is affected by dyslexia (Bundesverband Legasthenie und Dyskalkulie e. V., n.d.) while up to 20% of German adolescents experience psychological conditions such as anxiety, depression, or social behaviour disorders (Ravens-Sieberer et al., 2007), all of which can impact cognitive processing, learning behaviour, and attention span. Moreover, adolescents with migration backgrounds who have not yet acquired sufficient language proficiency may struggle with verbal career tests. Image-based assessments, such as the F-I-T, provide an alternative with greater accessibility.

However, the F-I-T and equal tests often still require scale-based evaluations, digital literacy, or the ability to rate and categorise a large number of items, which are challenging for certain participants. The test design presented in this thesis prioritises maximum accessibility and usability by utilising eye tracking technology. This method enables the assessment of vocational interests independently of language proficiency, digital competencies, or complex and time-consuming test procedures. In an eye-tracking-based vocational interest test, participants are only required to visually engage with presented stimuli, eliminating the need for textual comprehension. Images serve as direct representations of real-world occupational activities, can evoke positive or negative affective responses, and do not require textual decoding. They can also be designed to be diverse, multicultural, and free from stereotypes, ensuring inclusivity across different demographic groups. This approach, which emphasises concrete representations of professional activities while avoiding decontextualised or overly abstract content, aligns with recommendations from previous research on interest inventories (Weißmann et al., 2022).

A further advantage of visually assessing the strength of vocational interest is the reduced influence of social desirability on participants' responses. Research has shown that self-report methods, including Likert scales and verbal assessments, are often biased by prosocial tendencies, leading individuals to respond in ways that align with societal expectations rather than their genuine interests (Gordon, 1987; Guo et al., 2024; Kreitchmann et al., 2019). Such biases can obscure an adolescent's true vocational preference, reflecting instead parental ideals, teacher recommendations, social media trends, or peer influence. In verbal assessments, adolescents may unconsciously echo phrases they have heard from their social environment. For instance, if a common societal expectation is to ‘pursue a stable and prestigious career, such as becoming a doctor,’ an adolescent encountering a similar statement in a test (e.g., 'Rate your interest in working as a doctor in a hospital') may rate it higher than their actual inclination, influenced by external expectations rather than personal preference.

Image-based assessments present concrete occupational activities, engaging the working memory in processing and evaluating visual information. Emotional responses, such as liking or disliking an activity, drive visual exploration, reducing the likelihood of prosocial bias. For example, an adolescent with a passion for artistic expression may instinctively fixate on an image depicting an artist, even if their parents discourage a career in the arts in favour of a more 'practical' profession, such as banking. Given the time constraints and intuitive nature of eye tracking assessments, the participant's visual attention will likely be drawn to images aligned with their intrinsic interests, rather than those dictated by external pressures. To effectively guide adolescents in their career orientation, assessing their genuine preferences rather than those of their social environment is essential. Eye tracking offers a promising method for uncovering authentic vocational interests by capturing spontaneous, emotion-driven visual attention, minimising the distortions associated with social desirability.

A notable limitation of rating scales, particularly in the context of social desirability, is the presence of extreme response patterns. These response tendencies represent an underlying latent personality trait (Naemi et al., 2009). For instance, individuals often exhibit a predisposition toward selecting either the most extreme or the most socially desirable response option. This systematic response bias distorts the validity of scale-based self-reports, leading to measurement inaccuracies (Paulhus, 1991). Recent research highlights growing concerns regarding the impact of extreme response styles on assessment precision, inflation of measured relationships, and biases in the predictive validity of psychometric scales (Abad et al., 2018; Bolt et al., 2014; Weijters et al., 2010). A perception-based assessment of vocational interests presents a viable alternative to mitigate these biases. Unlike traditional self-report scales, visual search tasks are not subject to distortions caused by extreme response styles. Beyond that, the strength of vocational interest can be assessed with greater precision, as eye movement data is captured on a ratio scale, whereas self-report scores typically rely on ordinal-scaled Likert ratings. This approach allows for a more nuanced quantification of interest levels without the constraints of predefined categorical responses (e.g., 1–5 on a Likert scale). Moreover, participants engage in intuitive decision-making without explicit awareness of the lowest and highest parameters associated with the level of interest.

The last advantage of assessing vocational interests through eye tracking technology is the efficiency of the testing process. In the experimental studies, the image stimuli were presented for 30 seconds each. The entire assessment, including result presentation, required approximately eight minutes per participant. A practical demonstration of this efficiency was observed during a career counselling event, where 14 adolescents completed JobVision and received immediate feedback within two hours and one test leader. Eye tracking provides a real-time, direct measurement of vocational interests, enabling rapid yet significant results. In contrast, traditional scale-based assessments and other nonverbal tests require additional data transformations (e.g., conversion of raw scores into standardised values) and typically take between 15 and 30 minutes to administer. The current eye tracking procedure allows for the simultaneous presentation of six occupational activities, eliminating the need for participants to sequentially process numerous items and professions. This approach reduces cognitive load over a long time while facilitating a more intuitive decision-making process. The time saved can be reallocated to in-depth career counselling, enhancing the overall guidance experience. Additionally, from the participant's perspective, the shorter test duration reduces the attention span and increases the motivation, ensuring engagement throughout the assessment while preventing fatigue effects.

In summarising the strengths of the present thesis, several advantages of the test design outperform conventional scale-based vocational interest assessments. The most important advantage is that eye movement metrics provide objective indicators of cognitive processes. It enables a behaviour-based evaluation approach that mitigates biases associated with subjective self-assessment. Additionally, eye tracking methodologies can be effectively employed with individuals experiencing dyslexia or other psychological conditions that impair attention span or reading ability. Unlike traditional scale-based assessments, eye tracking tests are not susceptible to biases such as social desirability effects or extreme response styles. The last point is that eye tracking assessments yield results within a few minutes, whereas conventional vocational interest tests typically require up to 20 minutes. The time saved can be reallocated to other career counselling interventions, enhancing overall efficiency and counselling quality.

3.4 Limitations

The results offer several advantages for a behavioural assessment of vocational interest. Nevertheless, acknowledging the limitations inherent in this thesis remains important. The quality of the results is highly contingent upon task-specific variables, such as the duration of the test, the complexity of the visual stimuli, and the simplification of data analysis procedures. These limitations are discussed in the following sections.

In Study 3, the testing duration was considerably extended. The entire data collection took up to 30 minutes whereby the eye tracking part only lasted five minutes. This long testing time may have introduced biases related to participants' motivation and attention. As previously mentioned, these factors could have influenced the results, and therefore, the findings of Study 3 should be interpreted with caution.

To streamline the data analysis process, only twelve distinct professions were presented to the participants. Some participants reported that none of the depicted professions accurately reflected their vocational interests. This limitation must be considered when interpreting the findings, as the restricted range of professions may have resulted in a selection bias, favouring certain RIASEC types that do not truly align with the adolescents' interests. Due to the lack of alternative options, participants may have chosen a profession out of necessity rather than preference. Future research should incorporate a broader range of AOIs to ensure that every participant is presented with at least one profession that aligns with their true vocational interests.

Another simplification involved the use of the one-letter RIASEC code for data analysis, which was implemented to reduce analytical complexity. According to Holland (1997), vocational interests and work environments are classified into six distinct RIASEC dimensions. A three-letter-code with the three most relevant RIASEC types is generated in applied settings. The three-letter RIASEC code is essential for accurately assessing adolescents' vocational interests and deriving potential career paths. For a robust diagnostic evaluation of vocational interests, future research should use analytical methods that incorporate the three-letter RIASEC code, focusing on the three most salient RIASEC types for each individual. This can lead to a more precise person-environment fit and more variability in the potentially interesting job profiles.

Several technical limitations of the eye tracking and response time approach should be acknowledged, too. Eye tracking technology, particularly the high-sensitivity SMI eye tracker used in the studies, requires specific conditions to ensure optimal data quality. Various factors can influence the accuracy of the eye tracking data, including ambient lighting, the use of glasses, refractive errors (ametropia), and the participant's age. These variables can significantly affect the quality of the collected data. In the present studies, efforts were made to control for these factors to the best extent possible, e.g., measuring the lighting with a light exposure meter, favouring data from participants without glasses and excluding adolescents with ametropia.

Another technical challenge encountered was the stability of the internet connection during the administration of the AIST-3. Given that the doctoral studies were conducted in field settings within schools, the Wi-Fi connections at these locations were occasionally unstable, which affected the performance of the online platform used to conduct the AIST-3. Consequently, errors in response time were introduced, which were difficult to detect and correct. To utilise response time as a valid and reliable parameter, future studies should ideally be carried out under controlled conditions in a laboratory setting. This would mitigate technical challenges and improve the quality of data for assessing the career choice certainty based on response time. In this study, the absence of significant correlations with response time as variable contradicts previous findings in literature (Brunyé & Gardony, 2017; Saito et al., 2017). These studies were conducted in laboratory environments. The technical limitations arising from the weak internet connections may have introduced a bias that influenced the data.

In conclusion, several limitations must be considered when interpreting the results of the three studies. The restricted range of presented professions may have constrained participants' ability to identify an occupational activity that aligns with their vocational interests. Furthermore, the analysis utilised only a single RIASEC type to determine vocational interest, whereas career counsellors typically assess vocational interest using a three-letter code. The absence of a significant effect regarding the career choice certainty may be caused by methodological biases, including the extended duration of test administration in Study 3 and/or inconsistencies in internet connectivity at schools.

3.5 Outlook and future directions

This dissertation offers valuable insights for further research concerning the methodology, practical implementation, and unresolved research questions in the field. The primary objective of the three studies of this thesis was to provide initial empirical evidence supporting the assessment of vocational interests through eye movement analysis. Given that significant correlations between the strength of vocational interest and both dwell time and fixation count has been established, subsequent research should focus on evaluating the stability, reliability, and validity of these relationships. Further investigation is required to develop a diagnostic tool based on eye tracking technology that ensures a reliable and practical assessment. One future research question is concerning the temporal stability of RIASEC preferences–specifically, how vocational interests evolve over time and whether the initially assessed RIASEC profiles align with individuals' future career paths. A comprehensive analysis of all RIASEC dimensions is necessary, as certain dimensions (e.g., Realistic or Investigative) may exhibit greater stability and thus be more suitable for perception-based assessments. Moreover, the eye tracking test must be validated against other non-verbal assessment tools, such as the F-I-T (Jungo & Toggweiler, 2019), which is also based on the RIASEC model. Analysing the correlations between the RIASEC values from the eye tracking test and from the existing vocational interest tests will be essential to validate the significance of the eye tracking method and to determine the most accurate perception-based assessment approach. Additionally, comparative analyses should examine how these methodologies differ in terms of their quantitative and qualitative approach to obtain the best data for career recommendations.

Previous studies have demonstrated significant correlations between response time and decision certainty (Gvozdenko, 2010; Naemi et al., 2009). As noted earlier (see Section 3.1.2, page 135), various parameters influence response time in rating scales, necessitating a controlled laboratory environment to systematically analyse response time. A research question emerging from this issue could be: What methodological and technical conditions are required to reliably assess the career choice certainty using response time in standardised interest assessments such as the AIST-3? Beyond identifying these requirements, examining the relationship between response time and vocational interest is also important. In the present dissertation, these correlations were analysed using linear regression models. However, response time is classified as a reaction time variable and does not necessarily exhibit a linear progression (Börger, 2016). In Study 3, the response time followed a Weibull distribution, which may indicate a non-linear relationship between the eye tracking parameters and self-reported career choice certainty. To verify this hypothesis, the existing dataset could be reanalysed using non-linear statistical methods.

A final recommendation for future research involves integrating modern technologies into eye-tracking-based vocational interest assessment. The application of artificial intelligence (AI) for stimulus generation and the use of webcam-based eye tracking for data collection present innovative opportunities in this domain. As previously discussed, career counselling should align with the lifeworld of adolescents and leverage advancements in technology to enhance test methodologies. To develop an assessment tool that is both efficient and accessible, webcam-based eye tracking represents a viable alternative, enabling large-scale administration without dependence on test facilitators, specific locations, or rigid time constraints. Recent advancements in webcam eye tracking technology have established it as a cost-effective alternative to remote eye trackers (Kaduk et al., 2024; Wisiecka et al., 2022). While webcam-based systems are generally less precise than remote eye trackers (Kaduk et al., 2024), this limitation is mitigated in the present research design, as the stimuli are designed with large areas of interest, making webcam-based eye tracking sufficiently accurate for vocational interest assessment.

Furthermore, the integration of AI-generated occupational imagery can expand the number of career options presented to participants. At the onset of this doctoral research in 2021, AI-based image generation tools such as Midjourney and Adobe Firefly were not yet invented. A human illustrator manually created 12 occupational images and a background scene. However, recent advancements in AI image generation now allow for the efficient creation of additional occupational stimuli that maintain visual consistency with existing materials. The technological development offers a scalable and cost-effective approach to increase the diversity of the image stimuli. This directly addresses one feedback of the adolescent participants–the limited number of professional options presented. By leveraging AI-based image creation, the perception-based test can provide a broader and more representative array of career pathways, ultimately enhancing the validity and applicability of the assessment tool.

From both a psychometric and applied perspective, this dissertation offers substantial potential for further research and development. Future work can build upon the insights gained regarding effective test design, identification of significant perception-based parameters, and the conception of meaningful stimuli.

4 Conclusion

This doctoral thesis explores the influence of personality traits, specifically vocational interests, on individuals' visual perception. The aim of the thesis was twofold. Firstly, possible eye tracking parameters were defined which could be utilised to determine the strength of vocational interests. Secondly, behaviour-based metrics were analysed which offer the possibility to investigate career decision certainty. At the outset of this research, it remained unclear whether vocational interests could be reliably identified through eye movement behaviour. However, following three extensive field studies conducted with adolescents aged 16 to 19 in German schools and career fairs, it can now be stated with confidence that two eye tracking parameters are well-suited for this purpose. The findings demonstrate a positive correlation between the strength of vocational interest and both dwell time and fixation count within defined areas of interest. The RIASEC model proposed by Holland served as a theoretical framework for the development of picture stimuli and the subsequent analysis of the eye tracking data. Additionally, image-based evaluations proved effective in assessing adolescents' preferred RIASEC dimensions, aligning with previous research and established non-verbal vocational interest assessment tools. These findings contribute meaningfully to both interest research–particularly regarding vocational interests as stable personality traits–and the field of visual perception.

Regarding career decision-making, the results did not indicate strong effects between behaviour-based measurements (eye tracking and response time) and the career choice certainty. A minor but statistically significant correlation was observed in Study 2, where saccade count was weakly associated with the career choice certainty, as measured by response time in the standardised vocational interest test AIST-3. Distinguishing between intuitive and deliberate decision-making in career choices remains a complex challenge that requires further investigation.

From an applied perspective, assessing vocational interests through eye movement analysis presents a time-efficient testing method with practical utility for career counselling. The findings suggest that eye tracking could serve as an additional, data-driven tool to support career decision-making processes. The use of a gamified approach can significantly enhance motivation in the career decision-making process. A visual vocational interest assessment can offer valuable guidance through a first orientation with the help of the most frequently observed RIASEC types. This type of assessment not only supports individuals in clarifying their decision-making tendencies but also helps uncover involuntary career preferences. It facilitates an interest-driven selection from the extensive range of state-recognised apprenticeships and bachelor study programmes. The findings of this dissertation expand the knowledge of the influence of personality traits on visual perception. It demonstrates that interdisciplinary research can effectively integrate strengths from diverse fields, thereby leveraging their unique advantages to generate novel insights.

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In this context, I also wish to thank the school principals, teachers, and fair organisers who generously allocated time with their students or included my study in their program offerings. As I am unable to name every location due to space constraints, a complete list can be found in Appendix B on page 193. This list can be seen as a summary of gratitude.

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Ort, Datum und Unterschrift

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Appendix

Appendix A – Further analyses

Internal Consistency of the eye tracking parameters and the image query.

Number of items: 2.

	Cronbach's alpha
Dwell Time	
Realistic	**0.74**
Investigative	0.54
Artistic	0.54
Social	0.35
Enterprising	0.15
Conventional	0.001
Conventional 1/ Enterprising 2	**0.68**
Enterprising 1 / Conventional 2	**0.66**
Fixation Count	
Realistic	**0.71**
Investigative	**0.62**
Artistic	0.58
Social	0.36
Enterprising	0.17
Conventional	0.23
Conventional 1/ Enterprising 2	0.58
Enterprising 1 / Conventional 2	0.59
Image Query	
Realistic	0.55
Investigative	0.63
Artistic	0.36
Social	0.36
Enterprising	0.33
Conventional	0.40
Conventional 1/ Enterprising 2	0.28
Enterprising 1 / Conventional 2	0.69

Appendix B – Overview of data collection locations

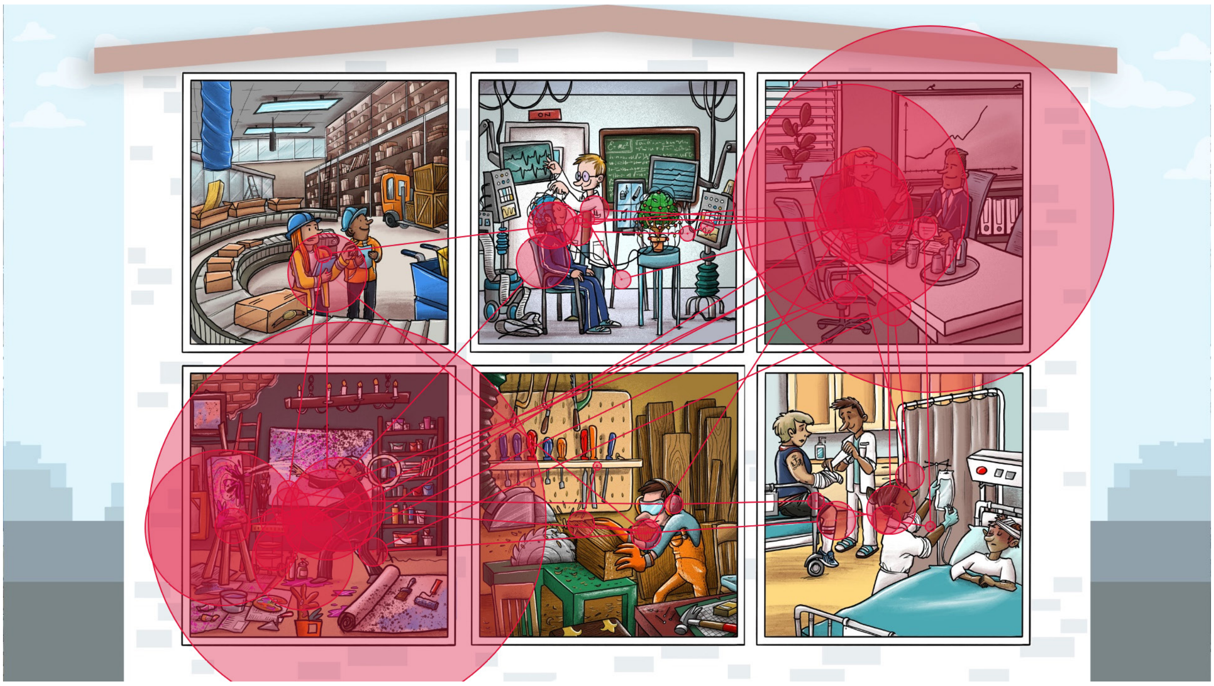
Schools	City
Technisches Gymnasium	73529 Schwäbisch Gmünd
St. Gertrudis	73479 Ellwangen (Jagst)
Schubart Gymnasium	73430 Aalen
HANSA Handelsschule	08468 Reichenbach
HANSA Handelsschule	08058 Zwickau
Rosenstein Gymnasium	73540 Heubach
Hariolf Gymnasium	73479 Ellwangen (Jagst)
Peutinger Gymnasium	73479 Ellwangen (Jagst)
Berufliche Fortbildungszentren der Bayerischen Wirtschaft	73431 Aalen
Technische Schule Aalen	73430 Aalen
Kaufmännische Schule Aalen	73430 Aalen

Fairs	City
Berufsinformationstag explorhino Science Center	73430 Aalen
Studienmesse Theodor-Heuss-Gymnasium	73430 Aalen
Start-it Ausbildungs- und Studienmesse	73430 Aalen
Jugend forscht Regionalwettbewerb	73430 Aalen
Berufsinformationsabend Rotary Club Aalen-Heidenheim	73430 Aalen
Vocatium Aalen	73430 Aalen

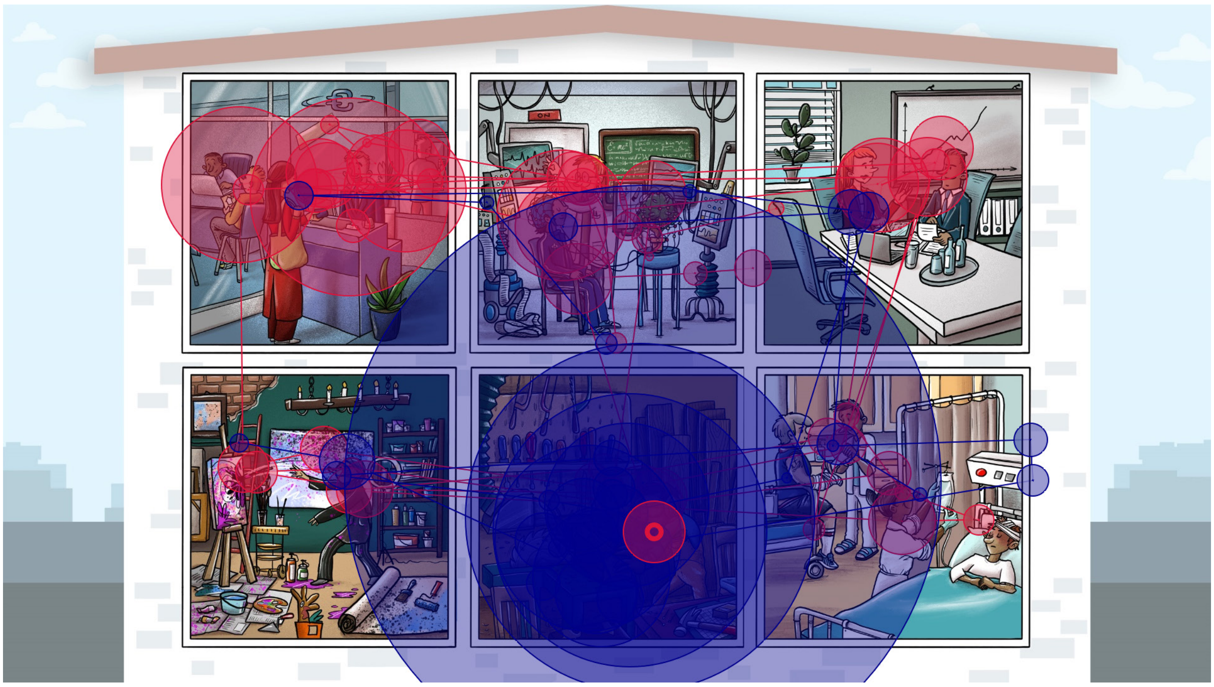
Appendix C – Scan path examples

Scan path examples for Stimulus 1 (Study 1, 2 and 3)

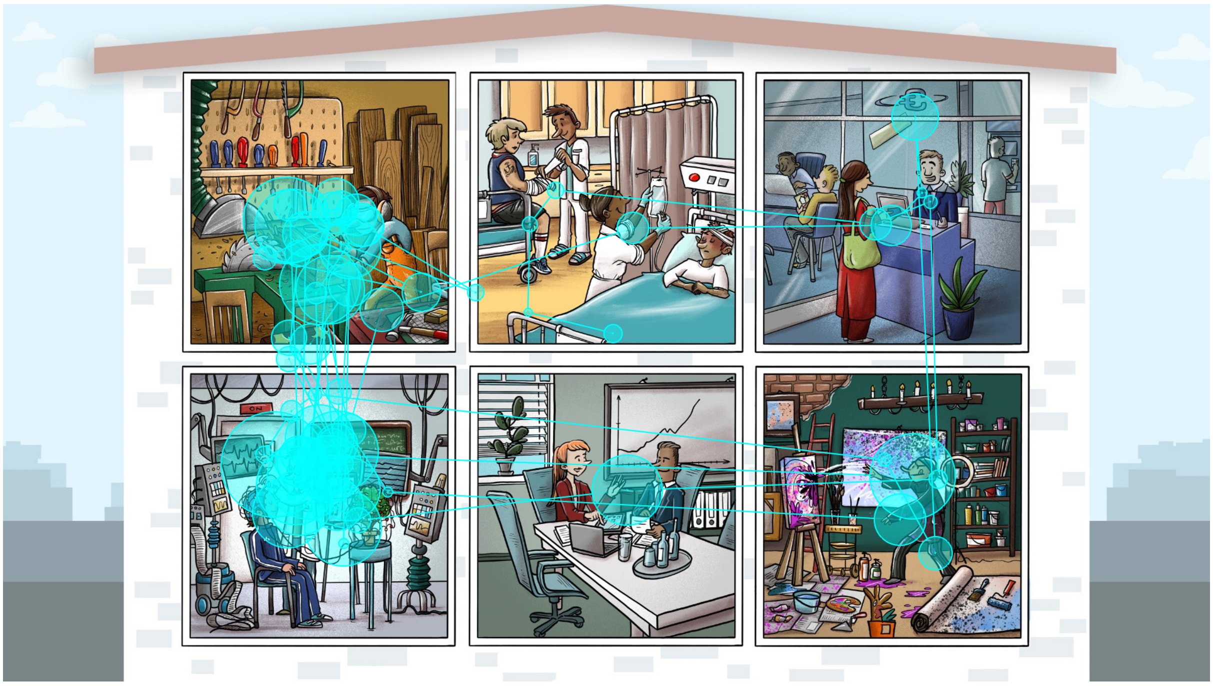
Each color represents an individual participant



Study 1: The female participant was interested in the Enterprising and Artistic dimension. Her fixations in these AOIs were particularly long and she paid little attention to the other AOIs. In this variant of stimulus 1, the logistician represents the dimension Conventional.

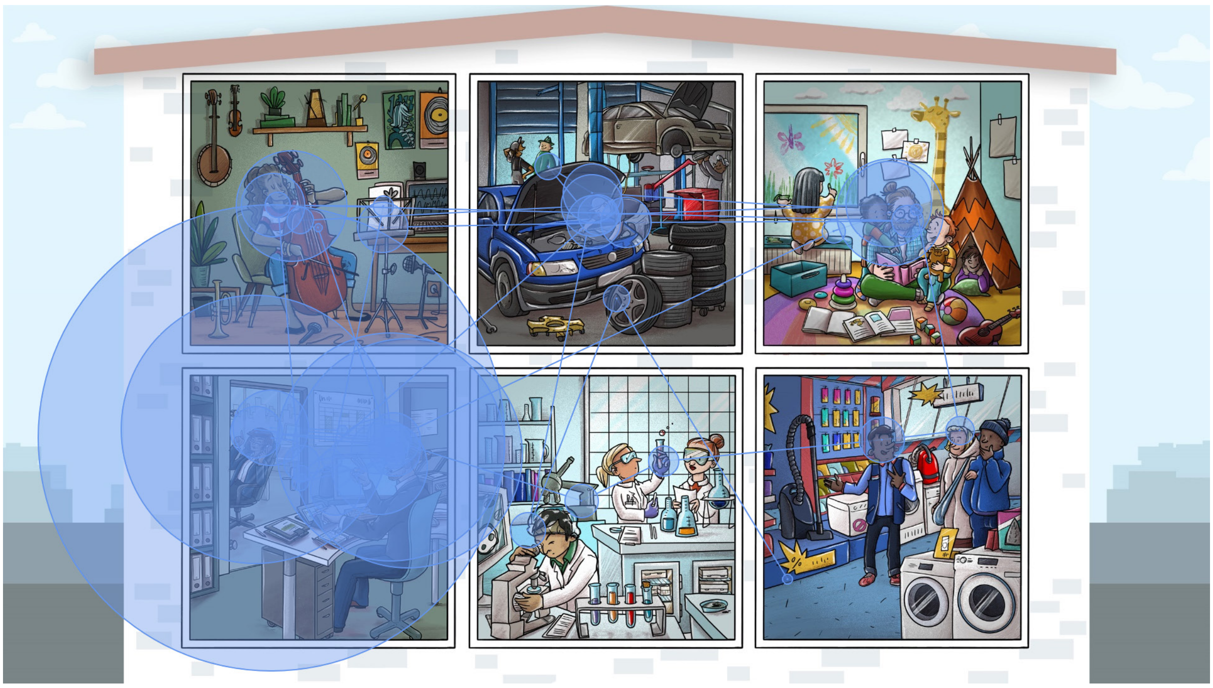


Study 2: Both participants exhibited focused viewing behaviour. The red participant (male) showed primary interest in the Conventional, Investigative, and Enterprising dimensions, while the blue participant (female) demonstrated a strong interest in the Realistic dimension. In this variant of stimulus 1, the bankers represent the dimension Conventional.

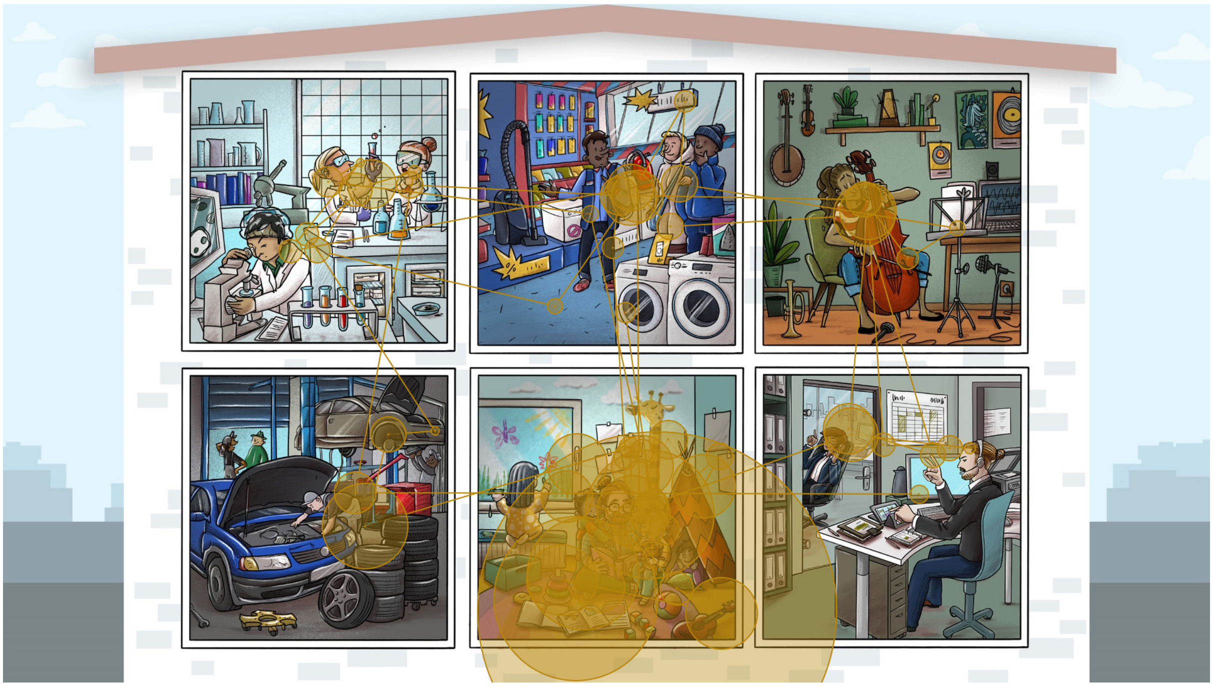


Study 3: The female participant exhibited short fixations primarily on the dimesions Realistic and Investigative. She often switched between these AOIs and looked at the faces and (inter)actions of the characters.

Scan path examples for Stimulus 2 (Study 2 and 3)



Study 2: The male participant fixated intensely on the Conventional dimension with a mix of longer and shorter fixation durations. Overall, he exhibited relatively few fixations, primarily focusing on the faces of the figures.



Study 3: The female participant demonstrated a clear interest in the Social dimension. She briefly scanned the entire image before directing her attention primarily to the Social AOI. Her fixations were mainly concentrated on the details within that scene.

Appendix D – Nutzung KI-Tools (deutsch)

KI-Tool:	**Genutzt für:**	**Warum?**	**Wann?**
ResearchRabbit	Stand der Forschung recherchieren	Relevante Autoren, Paper und Journals finden	Literaturrecherche und Veröffentlichung der Manuskripte
ChatGPT	Formulierung der Textentwürfe (datenschutzrelevante Passagen wurden ausgelassen)	Grammatik, Satzbau und Fachtermini überprüfen	Erstellung der Manuskripte und der Dissertation

Appendix E – Flyer JobVision