Charles University
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Assessment of Individual Game Skills of Ice Hockey Players on the Example of Puck Control

Dissertation

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I declare that I compiled this dissertation on my own under my supervisor's leadership, using only the listed sources and literature. I did not use this dissertation to obtain another academic degree.

Prague, September 2025 ……………………………

Signature

Evidenční list

Souhlasím se zapůjčením své diplomové práce ke studijním účelům. Uživatel svým podpisem stvrzuje, že tuto diplomovou práci použil ke studiu a prohlašuje, že ji uvede mezi použitými prameny.

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Abstrakt

Název: Diagnostika herních činností jednotlivce u hráčů ledního hokeje na příkladu uvolňování hráče s kotoučem

Cíle: Prvním cílem práce bude vytvoření nástroje k diagnostice herních činností jednotlivce v ledním hokeji.
Druhým cílem poté bude pomocí tohoto nástroje pro hráče ledního hokeje definovat standardy v oblasti uvolňování hráče s kotoučem.

Metody: V naší práci jsme použili teorii položkových odpovědí, konkrétně Raschovu analýzu a Mokkenovu analýzu, patřící mezi neparametrické modely teorie položkových odpovědí. Pomocí Raschovy analýzy jsme vybírali položky z položkové banky do diagnostického nástroje. Reliabilita byla vypočtena pomocí Cronbachovy alfy. Pomocí Mokkenovy analýzy jsme potvrzovali výsledky Raschovy analýzy a hodnoty reliability.

Výsledky: Byl vytvořen diagnostický nástroj zahrnující 17 položek. Diagnostický nástroj je sestaven do podoby Guttmanovy škály na základě obtížnosti položek. Pomocí vytvořeného diagnostického nástroje byly definovány standardy v oblasti uvolňování hráče s kotoučem v ledním hokeji pro hráče ve věku 6–15 let. Vytvořená metodika pro tvorbu diagnostického nástroje je vhodná k použití pro tvorbu diagnostických nástrojů pro posuzování dalších dovedností v ledním hokeji.

Klíčová slova: Raschův model, Guttmanova škála, Mokkenova analýza, položky.

Abstract

Title: Assessment of individual game skills of ice hockey players on the example of puck control

Aims: The first aim of the thesis will be to create a tool to assess an individual player's skills in ice hockey.
The second aim will be to use the developed assessment tool to define standards for ice hockey players in terms of puck control.

Methods: In our thesis, we used item response theory, namely, Rasch analysis and Mokken analysis, which belong among non-parametric models of item response theory. We used Rasch analysis to select items from the item bank for the assessment tool. The reliability was calculated using Cronbach's alpha. We used Mokken analysis to confirm the results of Rasch analysis and reliability values.

Results: An assessment tool consisting of 17 items was developed. The diagnostic tool is constructed in the form of a Guttman scale based on the difficulty of the items. The diagnostic tool was used to define standards in terms of puck control in ice hockey for players aged 6–15 years. The methodology created for the development of the assessment tool is suitable for use in the development of diagnostic tools for the assessment of other ice hockey skills.

Keywords: Rasch model, Guttman scale, Mokken analysis, Items.

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1 INTRODUCTION

Assessment methods are very common in ice hockey. Various types of diagnostic tests are used during the annual training cycle. Players are tested regularly during the off-season and pre-season, in some cases, tests are also employed during the season (Bournival et al., 2023; Douglas et al., 2022; Martini et al., 2018; Pavliš et al., 2003; Perez et al., 2022; Vigh-Larsen et al., 2019). The main purpose of assessment methods is to evaluate players' readiness for the ice hockey season by checking their training. To this end, functional medical examinations and sport motor tests are commonly employed. Tests of psychological aspects of training are used less frequently. The emphasis is therefore on assessing motor skills. Additionally, most assessments focus on non-specific motor skills and are conducted under laboratory conditions. Diagnostics of specific motor skills are utilised minimally. On the ice, in the specific game environment, players are hardly assessed at all.

Motor skills are only a prerequisite for performance in ice hockey. It can be said that ice hockey consists solely of skills, and there are a number of them. However, evaluating skills is less common. Moreover, players' skills change during ontogeny as their body proportions change. The degree of skill mastery also fluctuates due to the dynamics of skill learning and acquisition.

The monitoring of players' sporting performance is mainly conducted through training matches. Methods of direct and indirect observation, along with resulting expert analysis, are utilised. However, these analyses are often biased by the personal experience and knowledge of the expert. Especially during the school and adolescent period, coaches have varying demands on players when assessing their performance. In fact, standardised scales for assessing ice hockey skills are lacking in the literature.

Coaching and technique adjustment are matters requiring expertise. The basis of a skill lies in its efficiency, which can be enhanced through training and mastery, and for older players, it can be regulated by the quality of training (Bukač, 2014). Bukač (2014) further adds that the speed and tempo of the game are contingent on how well the player controls the puck.

Feedback is essential for effective player development, not only in ice hockey. A standardised assessment tool would aid coaches in identifying specific game activities that individual players should be able to perform. It would also indicate the level at which players should master these game activities. Standardised scales and tests of players' ice hockey skills could also help to enhance and streamline the training process.

The aim of this dissertation is to develop a standardised assessment tool that can be used to evaluate individual game skills of ice hockey players. Due to the aforementioned large number of different skills required in ice hockey, we will focus on puck control, which is considered one of the basic ice hockey skills in all developed ice hockey countries (Český hokej, 2018; Hockey Canada, 2018; USA Hockey, 2024).

Based on the literature review and interviews with hockey experts, we will create an item bank. Once the item bank is established, it will be calibrated, and Rasch and Mokken analyses will be utilised to develop an assessment tool in the form of the Guttman scale. This tool will be employed to define standards regarding player puck control in ice hockey for players aged 6–15 in the Czech Republic.

The outcomes of this research will contribute to a deeper understanding of motor learning and its principles. Kostka (1963) asserts that the methodology of training should continually evolve through scientific knowledge. Therefore, our effort will result in the development of methodological resources for ice hockey coaches in the Czech Republic. Given the absence of a standardised assessment tool for evaluating puck control skills among ice hockey players in international literature, as well as its non-utilisation by experts in practice, the findings of this study will have international significance.

2 LITERATURE REVIEW

2.1 Ontogenetic Basis for Assessment Tool Development

In ice hockey, an age-appropriate training approach is recommended, starting in childhood, taking into account anatomical, physiological, educational-psychological, and individual differences. The foundation is appropriate training in childhood, followed by peak training and performance in adulthood. It is essential to respect sensitive periods in the development of motor skills. In practice, the first stages of the training process in ice hockey begin at the end of preschool and the beginning of school age.

Perič and Dovalil (2010) lists the basic principles of long-term training as the principles of physical and psychological development and the principles of performance growth in a given sport.

The concept of age-appropriate training uses three to four basic stages that respect the development of the individual as well as the growth of performance in the given sport.

These stages include an introduction to the sport and basic training, specialised training, and elite training. This approach reflects the developmental patterns of late preschool and younger school age, older school age and adolescence, continuing into adulthood.

In ice hockey, the phase of introduction to the sport and basic training begins at the end of preschool age.

From around the age of six, children grow steadily and gain weight evenly. Because the skeleton is not yet fully developed, it is inappropriate to overload the spine and large joints. Children are always moving, they have a need to do something, and restlessness is characteristic of this period. New nerve structures are being formed and the rate of their stimulation and inhibition increases, which is a prerequisite for the development of speed and coordination.

Around the age of eight, the "golden age of motor skills" occurs, during which children learn new skills most easily. Fine motor skills improve, necessitating the incorporation of a large number of movements alongside the development of speed and dexterity skills. Play is highly recommended during this phase. With the maturation of the central nervous system, Vágnerová (2012) also notes a greater resistance to stress.

After the onset of puberty, there is a significant reduction in learning capacity and a decline in its quality. It is important to foster a relationship with play as well as a sense of responsibility. However, the sport should not be the "centre of the universe" for players of this age. Dovalil et al. (2009) argue that it is essential to build a healthy attitude to the sport.

Differences in skill acquisition, anatomy, physiology, or performance among individuals during ontogeny have been highlighted in papers such as Buttelmann and Böhm (2014), Dolganova and Grebenyuk (2008), Farber and Petrenko (2011), Kharitonova, Mikhalev, and Chklyayev (2000), Kurgansky and Shupikova (2011), Osinski (1989), Son'kin (2015), and van Grunsven, Njiokiktjien, Vranken, and Vuylsteke-Wauters (2003).

The disparities in individual development associated with skill acquisition and motor skills during ontogeny provide a rationale for the development of an appropriate assessment tool and the subsequent establishment of standards concerning player puck control in ice hockey.

Peric (2008) reports significant differences in movement quality during the school-age period, pointing out a critical phase at the end of the junior school period, which is marked by a reduced ability to learn movements and decreased movement quality from around the age of twelve.

Here again, the issue of differences in individual skills and abilities linked to developmental variations becomes apparent. A standardised assessment tool for different age categories and standards derived from it will be beneficial not only for coaches and methodologists but also for the players themselves to gain an insight into their skill mastery levels.

The mastery of technique and individual skills, coupled with the development of speed and agility, forms the foundation of sports training for children. Failure to master technique adequately during childhood may limit achieving peak performance later in life (Pavliš et al., 2003).

Bukač (2014) states that in the developed hockey world, significant attention is given to technique training. While game practice is important, it is not a sufficient means of training. Consistent stick technique training, overseen by a coach, should be integral to a player's training regimen.

Hence, assessing ice hockey skills appears appropriate, given the substantial differences between individuals. Without applying scientific procedures in the assessment, a simple subjective evaluation may lead to inaccurate conclusions.

The development of a standardised assessment tool to evaluate players' puck control skills and define standards in ice hockey seems imperative, not only from an ontogenetic perspective.

2.2 A Chapter on Hockey Systematics as a Starting Point for Assessment Tool Development

Existing methodological materials from hockey associations in the USA, Canada, and Czech Republic indicate that fundamental skills include skating, puck control, shooting, passing, and other skills derived from these. Skating is consistently cited as the first skill to be learnt, and in practical terms, skating is also prioritised in training. It can be said that skating forms the foundation and is also a natural prerequisite for ice hockey. As has been noted, without a perfect mastery of skating skills, it is impossible to reach the top level (Český hokej, 2018; Hockey Canada, 2018; USA Hockey, 2018).

The methodological materials of established hockey nations (USA Hockey, Hockey Canada, Czech Hockey) also emphasise skating as a foundational skill within the hockey system. In their recommendations for the training process, skating is always highlighted separately, either as a distinct component or as an implicit necessity for mastering other skills. This presupposition is also integrated into our work in developing the assessment tool, where skating is considered a necessary prerequisite for completing and mastering each item.

Puck control is identified as another critical skill in the methodological materials. Towards the end of preschool and the beginning of junior school, players who have already acquired basic skating skills should start to learn the basics of puck control (Pavliš et al., 2009).

Specifically, USA Hockey recommends in its American Development Model to start with puck control training on ice after mastering basic skating skills (USA Hockey, 2024). Similarly, the Canadian Long Term Player Development programme recommends the development of basic skating and puck control skills towards the end of preschool and the beginning of junior school (Hockey Canada, 2023).

Basic puck control skills are introduced early on, once players have established fundamental skating abilities and can manoeuvre effectively on the ice. Therefore, in addition to skating as a prerequisite for on-ice movement, as previously mentioned, puck control becomes the initial focus in children's ice hockey training.

Following the acquisition of skating and puck control basics, players progress to passing and receiving, with shooting being the final fundamental skill. As individual skills and game activities are mastered, even in the more difficult variants, they are combined, and as players mature, they progress to mastering game combinations and systems.

It follows that it is recommended to commence teaching puck control immediately after mastering the basics of skating or concurrently with skating instruction. This again underscores the necessity for developing an assessment tool for puck control.

The learning process for the game activity of puck control follows the same methodological lines as skating, beginning with off-ice preparation and basic demonstrations, then progressing to on-ice exercises such as stationary control, forward movement, and eventually backward movement. Techniques include short and long dribbling, controlling the puck in curves, slalom lanes, side-to-side dribbling, diagonal stickhandling (forward to back), overhand control, behind-the-body control, one-handed control, changing direction and speed, body deception, stick deception, fakes, shielding, and others.

Puck control is categorised among individual offensive play activities in ice hockey systematics, allowing players to create space or advantage for shooting or passing in all areas of the ice surface. It facilitates temporary numerical superiority and sets the stage for successful offensive actions. In the defensive zone, it enables players to break away from opponents to initiate attacks, while in the neutral and offensive zones, it drives crucial phases of attacks.

A correct execution of puck control requires a stick that is long enough for the player and the player's readiness in the hockey stance. The top hand should firmly grip the stick at the top end with a relaxed wrist, performing rotational movements and controlling the stick's extension. The lower hand should hold the stick loosely, adjusting its position up or down as needed. A correctly executed action is one without visually tracking the puck; instead, players should pay attention to the game around them and perceive the puck only peripherally. Common execution errors include improper grip, failure to hold the stick at the top end with the top hand, inadequate spacing between the hands relative to the action being performed, overly tight control by the top hand, and excessive grip pressure by the bottom hand without moving it. Other mistakes include incorrect stance, use of a stick that is too long or too short, and focusing on the puck rather than the surroundings.

After mastering puck control basics, players progress to passing and shooting, which require strength training and further refinement of puck control techniques.

Minor discrepancies exist in the systems used by various hockey-playing countries, such as differences in terminology or the timing of skill acquisition initiation, often reflecting variations in age group distribution.

Czech Hockey lists the game activity of advancing the puck as a superordinate term, encompassing skills such as puck management by cranking, turning, changing direction, and passing the puck on the skates. Within the Czech hockey system, the skill of deception and faking by manipulating the stick fall under the playing activity termed deception and faking. However, for the purposes of our work, we consider all these skills and activities of an individual, such as advancing the puck, as part of puck control.

Hockey Canada's Long Term Player Development plan includes the umbrella concepts of stationary and moving puck control for players under the age of thirteen, further listing specific skills such as narrow and wide dribbling, side-front-side, toe drag, control in front of the body, control on the side, and others. Under individual offensive tactics, dekes and fakes with the stick and body are listed as the umbrella concept. Finally, for U15 and U18 players, all the above skills and game activities are combined under individual offensive puck control plays, while puck protection and management are addressed under team play and offensive skills. Again, for our purposes, we again view the term puck control as encompassing all the skills listed.

Similarly, USA Hockey uses the term puck control as an umbrella term for all related skills.

Considering the above, it is appropriate to treat puck control as a distinct skill, justifying the creation of an assessment tool specifically for puck control skills. Similarly, the skill of skating can be considered a necessary condition for movement, but it does not directly affect the separate skill of puck control for the purpose of creating an assessment tool. Skating is not considered, even though it is a natural prerequisite for completing each item. Therefore, our approach in developing the assessment tool and collecting data for the definition of standards will prioritise puck control skills over skating skills.

Given our focus on puck control for players aged 6–15 years, it is essential to examine individual skills and their acquisition period in line with methodological recommendations and player ontogeny.

Differences in recommendations among national associations (Czech Hockey, USA Hockey, and Hockey Canada) include the division of periods. Hockey Canada categorises players into periods of up to 7 years (U7), up to 9 years (U9), up to 11 years (U11), up to 13 years (U13), and up to 15/18 years (U15/U18). In contrast, USA Hockey uses periods of up to 8 years (U8), 10 years (U10), 12 years (U12), 14 years (U14), and finally 16/18 years (U16/18), respectively. Czech Hockey and methodological materials then list the period up to six years, followed by each subsequent year up to 15 years.

2.2.1 U8

For players at the end of preschool and the beginning of junior school, mastering the fundamental skills is paramount Players should learn the basics of the hockey stance and hand movement for puck control, including narrow and wide stickhandling while stationary and in motion, as well as stickhandling in front of and to the sides of the body (both forehand and backhand) both on the spot and on the move.

Additionally, Czech Hockey suggests that players under the age of eight should learn the basics of deking, controlling the puck in turns, and executing simple slalom manoeuvres while moving forward.

Hockey Canada recommends practicing weaving with the puck, open ice carry (both forehand and backhand), and utilising body and stick fakes.

Finally, USA Hockey adds puck control between the opponent's feet and stick, practising the attack triangle.

Both USA Hockey and Hockey Canada emphasise the importance of using the heel and toe of the stick when controlling the puck in front of and to the sides of the body.

2.2.2 U10

For players aged 9–10, the emphasis remains on further improving narrow and wide stickhandling while in motion and during turns, as well as mastering stickhandling from front to back, executing dekes, and practicing puck protection.

Czech Hockey also recommends drills such as puck handling in slalom lanes, skating forward and backward while incorporating skill elements such as jumping or passing obstacles, and executing puck control techniques while skating backward and at speed. Additional skills include forehand and backhand dekes ("around the world"), wide one-handed dekes (using only the upper hand), and the basics of faking.

Hockey Canada recommends practicing one-handed forehand and backhand puck handling and combining previously learnt skills.

Finally, USA Hockey suggests mastering acceleration with the puck, one-handed puck control, and changing pace during play.

2.2.3 U12

In the U11–12 category, players continue to refine and automate the skills they have acquired.

Czech Hockey recommends focusing on puck management without visual control, practicing various dekes with body fakes, mastering changes of direction and speed, executing fake passes or shot fakes to create one-on-one situations, and controlling the puck in exposed areas of the rink, such as corners.

Additionally, USA Hockey recommends incorporating directional changes while handling the puck, practicing puck control while skating backward, perfecting deceptive skills, and retrieving the puck from the rim.

For this age group, Hockey Canada does not add any skills other than those above but focuses on mastering and automating previously learnt skills and combining them into more complex tasks.

2.2.4 U14

The age period range of 13–14 years is characterised by further mastery and automation of previously acquired skills, performing activities without visual guidance, and executing skills under coordination-intensive conditions. Additionally, there is a beginning focus on small-area performance.

Czech Hockey recommends refining execution in game situations, emphasising puck control during tight turns and across all areas of the ice rink.

Hockey Canada emphasises the importance of focusing on range of motion in puck control and hand speed, both while stationary and in motion.

Finally, USA Hockey introduces deception while on the move as an additional skill to be developed at this stage.

2.2.5 U16

Up to the age of 15–16, the emphasis shifts towards executing previously acquired skills under challenging conditions, including time and space pressure, and combining all these skills effectively.

Hockey Canada adds the necessity of mastering puck protection in crowded situations, driving to the net, fostering creativity, and carrying the puck with speed.

Furthermore, USA Hockey highlights the importance of controlling the puck on the forehand while skating backward.

Czech Hockey also recommends maintaining puck control during specialised skating manoeuvres and managing the puck during multiple changes of direction.

Following from the above, it can be said that the skills recommended to be mastered by the methodological materials are very similar. Only minor differences can be found in the recommendations for the beginning of each skill acquisition and its first introduction. These minor variations can be attributed to differences in methodology conception over time, to differences in language, and to inconsistencies in methodological classification, including the "slang" of the coach not always corresponding to the methodology. Additionally, some materials may provide more detailed descriptions of skills than others. Given these variations, developing an assessment tool tailored to differentiate skills among players aged 6–15 is justified. By constructing the tool as a Guttman scale, it will offer immediate insights into a player's level of puck control mastery at the end of this developmental period.

2.3 Laws of Motor Learning as a Basis for Assessment Tool Development

Play and learning are among the most fundamental human activities. In general, learning can be described as an active and creative process involving the acquisition and development of knowledge, skills, abilities, attitudes, and norms. One specific type of learning is motor (sensorimotor) learning.

Motor learning denotes a continuous process of mastery and refinement of motor skills. These changes occur across various levels, stages, sections, and most commonly, phases.

Given the multitude of motor skills and their characteristics, defining a universal acquisition process is nearly impossible. However, the different stages of motor learning share common characteristics and criteria that are specific to them. This is applicable both from the athlete's perspective – including motor manifestations and nervous system connections – and from the perspective of the coach.

The phases of motor learning are interconnected and build upon each other, although their exact timing is not always clear, and they flow seamlessly into one another.

During motor learning, three to four phases can be discerned according to qualitative differences. In international literature e.g., (Huber, 2012; Krakauer et al., 2019; Lindsay et al., 2022), three phases are most common, while Czech literature introduces a potential fourth phase. However, it is not clear whether this is still a learning phase or whether we can talk about the highest level of sport mastery. International literature typically uses the terms cognitive phase, associative phase, and autonomous phase. Czech literature e.g., (Dovalil et al., 2009; Jansa et al., 2012; Perič & Dovalil, 2010) labels the phases of motor learning in terms of their external manifestations or in terms of the processes occurring in the central nervous system, progressing from initial learning to sport mastery. With respect to external manifestations, the phases include generalisation, differentiation, automatisation, and creative coordination. In terms of central nervous system processes, we distinguish the phases of irradiation, concentration, stabilisation, and creative association.

According to foreign literature, the cognitive phase involves familiarization with the skill and initial attempts at execution. This phase is marked by high mental activity, uncoordinated movements, and engagement of multiple muscle groups. The associative phase, also called differentiation and concentration, involves rehearsal and repetition. Reinforcement and feedback are essential in this phase. The phase is characterised by correct but imperfect and inefficient execution, with the mental control of movement at an intermediate level. The autonomous phase, also called automation and stabilisation, involves further skill refinement, coordinated movements, fluidity, economy, and automation. Skills are characterised by a high level of retention, while mental control is at a moderate level.

The fourth phase, called creative coordination in terms of external manifestations and creative association in terms of central nervous system processes, entails automated skills combined with creativity, involving a high level of mental activity, anticipation, and transfer. This phase represents mastery in sport.

There are five types of learning in the motor learning process; namely, imitational, instructional, feedback-based, problem-based, and ideomotor, with the first two being the most common in children. However, learning is not always linear. Rather, it follows learning curves, with positive factors pushing the curve upwards and negative factors pushing it downwards.

The evolving dynamics of learning have been highlighted, for example, by Ghorbani and Bund (2017) and Kalinski, Jalaska, and Labrovich (2016).

The variable dynamics of individual learning and acquisition of ice hockey skills are additional reasons to develop an assessment tool in ice hockey, create expert diagnostic scales, and define standards based on these scales.

Motor learning leads to the development of skills. The basic characteristics of a learnt skill include quality, speed, economy, and method of execution. A taxonomy of skills is utilised to differentiate skills, training methods, and performance requirements. There are numerous classification criteria. For instance, according to the criterion of dominant tendency in the learning process, motor skills are divided into input-dominant, output-dominant, and cognitive-dominant; according to the principle of familiarity, skills are divided into known and unknown.

The topic of motor learning is complex, as evidenced by the number of recent research papers (Brocken et al., 2016; Carter et al., 2016; Daou et al., 2016; Di Tore et al., 2016; Ghorbani & Bund, 2016; Gredin & Williams, 2015; Moreno & Ordono, 2015; Ranganathan et al., 2016; Shinpei et al., 2014; Verburgh et al., 2016). Therefore, it is appropriate to address the assessment of an individual's hockey skills. A suitable standardised assessment tool and standards based on it will help to provide feedback on the training process.

2.4 Theoretical Background for Data Processing Diagnostic Tool Development

Item response theory has been used in the literature to establish standards (Edelen et al., 2009; Jin & Wang, 2014; Myers et al., 2006; Primi et al., 2016; Reise et al., 2011; Sideridis et al., 2016; Tourón et al., 2012). This theory, rooted in statistical-probabilistic relationships, primarily focuses on the analysis of binary data.

In kinanthropology, various types of tests and rating scales are employed to assess skills. For their development, cross-disciplinary literature widely recommends the Rasch model (Anshel et al., 2009; Avery et al., 2003; Hecimovich et al., 2014; Ibrahim et al., 2015; Kang & Kang, 2006; Velozo et al., 2009; Zhuang, 2014) and Guttman scale constructions (Bertoli-Barsotti & Bacci, 2014; Krneta, 2014; LANGENDORFER & CHAYA, 2010; Sporiš et al., 2017; Tractenberg et al., 2012).

According to Čepička (2003), the Rasch model is gaining popularity in the assessment of motor skills.

The Rasch model was developed for analysing binary data. It assumes equal discriminability parameter values for all items. Another requirement is that items cannot be guessed and that it is unidimensional. Hence, based on the Rasch model, we aim to estimate the relationship between the probability of correctly answering an item and the requisite level of ability to complete said item. Consequently, we illustrate the relationship between the respondents' latent trait level and their item response score. When the latent trait level is higher than the item difficulty, the probability of success increases, and vice versa. When item difficulty aligns with the respondent's latent trait level, the probability of completing the item is fifty percent.

These properties of the Rasch model are instrumental in constructing an assessment tool. When we know the difficulty of the items, we can organise them in the form of a Guttman scale to develop a suitable assessment tool for evaluating an individual's in-game skills in ice hockey.

The term Guttman scale encompasses here not only a specific type of scale but the entire scaling technique, the process or the ideas used to create a given scale with certain characteristics. The literature also uses the term ideal or perfect scale (Gothwal et al., 2009; Kempf-Leonard, 2004; Davis-Stober et al., 2015). All these labels are based on the premise that completing an item of a certain difficulty on a given scale should imply automatic completion of all items of lower difficulty.

In developing an assessment tool to quantify a theoretical concept, we establish a means of quantification across a low–high range with a certain number of intermediate levels. Therefore, if the proposed scale items assess a common latent variable, the interrelationships between these items are pivotal (Čepička, 2001).

Consequently, the Guttman scale and Rasch analysis serve as suitable means for creating the assessment tool and defining standards of puck control in ice hockey.

2.4.1 Item Response Theory as a Basis Assessment Tool Development

Item Response Theory (IRT) is not a theory in the traditional sense. It does not explicate the reason behind a given response or how it was elicited. Rather, it functions like a theory of statistical estimation (Falmagne, 1989).

Specifically, IRT employs items and latent participant characteristics as predictors of observed responses. One advantage of IRT is that both the participant (represented by the latent trait level) and the item (represented by the difficulty) are placed on the same scale. Most IRT models then assume that the latent variables are unidimensional (Embretson & Reise, 2000). Additionally, for an item to be useful, it must have the capacity to discriminate between individuals with differing latent trait levels, thereby occupying different positions on the scale. This discriminative ability of an item reduces the unreliability in determining scores on the scale. Item discrimination ability may either remain constant or vary. Therefore, participants are characterised by the location of their latent variable and the items, at least in terms of their ability to discriminate between participants. Essentially, IRT involves a regression of the observed response of the individual on the latent characteristics of a level and the latent characteristics of the items. When an appropriate model is selected and the data fit the model, IRT offers several advantages over the Classical Test Theory. For instance, the estimate of the participant's latent characteristics is independent of the item, the precision of the estimate is unaffected by other items, and the difficulty of the items is independent of the participant. Moreover, it allows predicting the participant's performance and repeatedly validating the fit of the model (de Ayala, 2009).

De Ayala (2009) observes that IRT is based on several assumptions that should be adhered to, although in practice, these assumptions are often violated. These include the assumptions of dimensionality, conditional independence, often identified with the assumption of unidimensionality, and the assumption of functional form.

Furthermore, IRT models assume that responses are manifestations of one or more latent traits of the participant. This is known as the assumption of dimensionality. When focusing on a single dimension or a single latent trait, as in our research, it is referred to as the unidimensionality assumption. More specifically, the unidimensionality assumption posits that observations on a manifest variable (item) are solely a function of a single latent variable. However, there are instances where this assumption is violated.

This may or may not be a problem: even if the data reflect two latent variables, a unidimensional model may still provide sufficiently accurate information (de Ayala, 2009).

Using the model to estimate the latent variable then becomes a matter of validity, where we verify whether the estimated latent trait aligns with the intended measurement.

The assumption of conditional independence states that a participant's response depends solely on the level of the latent trait and not on other responses. Therefore, the assumptions of conditional independence and unidimensionality are sometimes combined into one and the same. Particularly in cases of time-limited measurements, specific models must be employed (Verhelst et al., 1997; Roskam, 1997).

Another assumption is the functional form assumption, which posits that the data adhere to the function specified by the model. For one-parameter models, this implies that all items in the assessment tool exhibit a characteristic curve with the same lower asymptote and slope. Consequently, the slope is determined by the same value of the discriminability parameter, resulting in parallel curves. However, this assumption is rarely fulfilled in practice.

Nevertheless, if the curves are parallel within the sampling error, it can be interpreted as the data fitting the model (de Ayala, 2009). Therefore, model fit is evaluated based on how well the data conform to the model (Janulis, 2014).

Čepička (2002) presents three fundamental principles for employing IRT: unidimensionality, local independence, and nonlinear dependence. Unidimensionality assumes that items measure only one characteristic, independent of the distribution of the latent trait in the population. Typically, it is assessed by evaluating the model's fit to the data. Local independence asserts that for a given value of the latent trait, the observed variables are probabilistically independent, meaning that the result of the test is independent of other tests. It depends only on the level of the latent trait. The specified level of the latent trait can vary only randomly, ensuring that at a fixed level of the latent trait, two items are uncorrelated. According to Čepička (2002), the third principle is often omitted because it is implicit in the probabilistic expression of the functional relationship between the latent trait and item success. This principle stipulates that the characteristic curve should never assume the values of 0 and 1, describing the principle of nonlinear dependence.

The prevailing approach in IRT involves working with conditional probability, where the trajectory shape is determined by the item function. We distinguish between the latent trait parameter, where we observe its level, and the item parameter, which is derived from the difficulty, discriminability, and guessability parameters. The difficulty parameter in IRT is independent of the number of participants or the level of the latent trait in the population. It is therefore not a proportion of correct and incorrect responses. "The discriminability parameter serves as an indicator of item validity with respect to a latent trait" (Čepička, 2002, p. 87).

It aims to extract maximum information from the response. The criterion is then not the mean but only the item difficulty and the value of the latent trait. The response provides full information about the item difficulty as an indicator and the level of the latent trait. In fact, IRT attempts to determine the level of the latent trait based on each individual response. Unlike the classical test theory, IRT assumes that error is a function of the latent trait, allowing any set of items to be used for assessment regardless of test length. However, maintaining the assumption of unidimensionality, where all items measure a single latent trait or characteristic, is crucial. The primary advantage lies in having both latent trait and difficulty values on the same scale, with difficulty estimation being independent of the participant set (Čepička, 2002).

2.4.1.1 The Characteristic Curve

Generally, IRT endeavours to mathematically represent the correct response to an item based on the respondent's latent trait level. This conditional probabilistic relationship can be described as a functional dependence, where the probability of a correct response is a function of the latent trait. This relationship is depicted by a characteristic curve, which graphically illustrates the connection between the dependent variable (i.e., the probability of response) and the latent trait as the independent variable. For binary data, this relationship is nonlinear. The fundamental assumptions of the characteristic curve are that it must be monotonically increasing, and its upper and lower asymptotes must lie within the maximum range of 0 to 1. The shape of the distribution function curve of the normal distribution of cumulative frequencies aligns with these conditions.

According to Čepička (2002), the difficulty of an item remains unaffected by its placement in another test; thus, it exists independently. It is not influenced by the pool of respondents or the test, unless changes occur to the item or the assumptions underlying its utilisation. Furthermore, distinguishes between two primary types of parameters: the latent trait parameter and the item parameter. The latent trait parameter represents the true value estimated from the observed value obtained through testing. Although the overall level for the entire test can be expressed by summing the values of all the items, the parameter value is estimated separately for each item, irrespective of the test. It signifies the level of skill or ability.

The item parameter determines the shape of the characteristic curve based on the model employed and the type of probability dependence of the latent trait. Depending on the model used (1PL, 2PL, or 3PL), parameters of difficulty, discriminability, and guessability are used. One of the fundamental features of IRT is item invariance. This implies that a respondent's answer depends solely on the level of the latent trait and nothing else. Hence, if the data fit the model, neither the parameters of the item function nor the shape of the characteristic curve change.

The discriminability parameter (a) shapes the curvature of the curve; in other words, its steepness. It represents the steepness with which the item is able to discriminate respondent responses of equal difficulty. The steeper the curve, the greater the discriminating capacity of the item. The highest values of this parameter are for items on which a respondent with a low level of the latent trait always responds incorrectly and a respondent with a sufficient level always responds correctly. The discriminability parameter is characteristic of two-parameter models.

One-parameter models use only the difficulty parameter (b), which is on the same scale as the latent trait parameter. It shifts the characteristic curve horizontally. Its value is constant regardless of the test set and is also independent of the test set. In models that use the guessability parameter and include items that can be guessed, the difficulty parameter is higher by the value of the guessability parameter alone.

The guessability parameter (c) represents the probability that a person without the required level of the latent trait will guess the correct answer. If the item cannot be guessed, its value is zero. If the item can be guessed, it represents the value of the lower asymptote. It is used in 3PL models.

Therefore, the key is to choose the right model to fit the data and its characteristic curve to best capture the estimate of the item response probability (Gu & Gutman, 2017; Janulis, 2014; Liao et al., 2012; Saltychev et al., 2018).

The IRT uses the logit[1] scale, which is logically similar to the z-score scale. Logits allow all mathematical operations to be performed without loss of meaning. The advantage is that both the difficulty parameter and the latent trait can be placed on the same axis, with units of the same interval length and additivity. In practice, the range of {−3, +3} is most commonly used, as the items have very low validity beyond this range.

The logit expresses the transformed mean of the variable being explained. In other words, it also expresses the probability that the variable Y takes values of 1. For a given value of the difficulty parameter and the same value of the latent trait, the probability of a correct answer is fifty percent (Pecáková, 2007).

2.4.1.2 Item Response Theory Models

Item response theory models are used to determine the probability of answering an item correctly as a function of latent trait level. Their basic characteristics are unidimensionality and an increase in the probability of a correct response as the level of the latent trait increases.

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[1] In determining the difficulty of items, this paper will always use the term "logit" based on the above logic, where its value away from zero indicates the simplicity or complexity of the item (depending on the approach and calculation logic used).

At present, item response theory covers numerous models that are constantly being modified or further developed based on existing ones. Their use has extended beyond the boundaries of psychology to various other disciplines.

Just as there are many models, there are also many criteria by which they are classified.

The most common classification includes the one-parameter (1PL), two-parameter (2PL), and three-parameter (3PL) models mentioned above.

Another classification criterion is based on the number of dimensions of the measured characteristics, dividing models into unidimensional and multidimensional. In our work, we focus on a single dimension, the player's puck control skill, so we will continue focusing on unidimensional models.

Another criterion for dividing IRT models is the type of item response. Here, we distinguish between dichotomous and polytomous models. Dichotomous models are primarily intended for items that are scored 0/1, yes/no, or pass/fail. Accordingly, they are mainly used for binary-scored items and are commonly found in tests designed to assess performance (Anshel et al., 2009; Čepička, 2001; Hecimovich et al., 2014; Ibrahim et al., 2015; Velozo et al., 2009; Zhuang, 2014). Secondary dichotomous models are used for items whose responses span multiple categories but are still scored binary. Based on the successful use of dichotomous models, polytomous models have also begun to be developed and applied in performance testing (Jelínek et al., 2011).

As our research focuses on performance, specifically on the skill dimension, we will also use a dichotomous model for binary-scored items.

2.4.1.3 Dichotomous Models

The basic types of dichotomous models include the one-parameter model (1PL), the two-parameter model (2PL), and the three-parameter model (3PL). The latter is sometimes supplemented with or extended by a fourth parameter (4PL).

The one-parameter logistic model is sometimes identified with the Rasch model and distinguishes items based on difficulty. The two-parameter model then adds discriminative efficiency to difficulty, where item difficulty also indicates how well the item can discriminate among individuals with different levels of the latent trait. The three-parameter model adds a third parameter in the form of pseudo-guessability, meaning how well the item can be passed by guessing or luck. The fourth parameter is then an extension of the sloppiness or underestimation of the item.

2.4.1.4 One-Parameter Logistic Model

As we will be using a one-parameter model in our work, we will explain it in more detail. The one-parameter logistic model is the simplest model. It is based on the fact that the probability of responding to an item is only determined by the difficulty of the item or the level of the respondent's latent trait (He, 2014).

Since the characteristic curve of the model has a monotonically increasing shape (Warne et al., 2012), it can be inferred that the higher the level of the latent trait, the closer the probability of a correct response is to one, and vice versa.

The difficulty of an item is defined as the point on the scale at which the level of the latent trait corresponds to a 50% probability of answering the item correctly. The difficulty parameter (b) is on the same scale as the respondent's latent trait. This is one of the major advantages of IRT, where we are able to estimate the respondent's response to an item using the characteristic curve, given knowledge of the respondent's latent trait. The individual trajectories of a single-parameter model of the same test differ from each other only by a horizontal shift to the left or right. The higher the parameter value, the more difficult the item.

When we assess a respondent's latent trait, we obtain a more or less accurate estimate of its level, hence we also assess the standard error of the estimate. For IRT, this is called the conditional standard error because it depends on the level of the latent trait. The standard error of the estimate increases towards the extremes of the latent trait. This is due the fact that the parameter is most accurately estimated when we have a large number of responses from respondents for whom the item is sufficiently difficult. This is also related to the item information function. The information potential of an item is greatest at the item difficulty point, that is, the 50% chance of a correct response. It follows logically that the item information function decreases towards the extremes of the respondent's latent trait. Thus, for the one-parameter model, the raw score presents the complete information for estimating the level of the respondent's latent trait.

2.4.1.5 Rasch Model and One-Parameter Logistic Model

The Rasch model assumes that items cannot be guessed and that the value of the discrimination parameter is the same for all items, equal to exactly 1. The Rasch model describes the relationship between the level of a latent trait and the response to an item. A higher level of a latent trait increases the probability of answering an item correctly, and vice versa. Given the same level of latent trait and item difficulty, the probability of a correct response is 50%. In practice, achieving the same discrimination parameter is challenging. Therefore, items with excessively high or low values are often removed from the test.

Although the one-parameter model and the Rasch model are sometimes considered different due to their implementation in measurement, mathematically, the models are the same. The Rasch model has been used as a standard in the development of assessment tools (Avery et al., 2003; Čepička, 2003; Dragounova, 2018; Jin & Wang, 2014; Kang & Kang, 2006; Myers et al., 2006). From this perspective, it is crucial that the data fit the model when it is used. When the data do not fit the model, then the items whose data do not fit the model should be removed from the diagnostic tool. The one-parameter model, on the other hand, is viewed so that the model should fit the data. If the model does not fit the data, another model should be used. The models are mathematically equivalent. However, for some, the Rasch model may represent a different philosophical perspective compared to the one-parameter models. One-parameter models focus on the fit of the model to the data, whereas the Rasch model is used in the construction/selection of the variables (items) of interest. De Ayala (2009) notes that the condition that the data fit the model must be met. Therefore, it can be said that the Rasch model is suitable for the creation of assessment tools.

For both models, and for IRT in general, the graphical form of the predicted probability of a correct response (1, yes, true) to an item is a characteristic function. Since all one-parameter models have a constant value for the discrimination parameter (a), the item characteristic curves differ only in the horizontal shift to the right and left. The position of an item on the scale is defined by the location of the inflection point of the item characteristic function.

It is characteristic of both the one-parameter and Rasch models that the items have a constant value of the discriminability parameter (a). The Rasch model uses a value of 1, while in one-parameter models the value can be different from 1 (de Ayala, 2009) but is always constant as well. The items differ only in difficulty, that is, in the value of parameter (b) at the location on the scale.

In one-parameter models, the responses are conditionally independent. This assumes the unidimensionality of the construct and the consistency of the data with the model. The unidimensionality assumption states that individual responses can only be explained by a single latent trait. The conditional independence assumption states that the response to one item is independent of responses to the other items. It is conditional only on the level of the latent trait, and this must be verified.

In contrast to classical test theory, respondents and items are placed on the same scale, although the location of the items may differ. The discriminative power of the items is constant for all one-parameter models. For all one-parameter models, the sum of the responses (i.e., observed scores) provides complete information for estimating both the latent trait level and the difficulty parameter, that is, the location of the item and the respondent's skill level.

The accuracy of the estimation of the item and respondent, or their difficulty and latent trait level, is given by the standard error. The smaller the error, the more accurate the estimate, and vice versa. The accuracy of the parameter is also reflected in the concept of information. Each item also provides the information contribution of the trait relative to the estimator. The sum of the item information functions of a given assessment tool provides the total information function. This can be used in the design of assessment tools.

On a standardised scale (e.g., using z-scores, logits), lower values represent easier items or lower levels of a latent trait, and conversely, higher values represent more difficult items and higher levels. The position of the item is usually denoted by the Greek letter δ (delta). The Greek letter θ (theta) is used for the latent trait level. The advantage of placing item difficulty and latent trait level on the same scale is that it allows the typical response to the item to be predicted. For those with latent trait levels at the lower end of the continuum, items at the upper end of the continuum will be difficult and the prediction of their response will be 0 (wrong/fail), and vice versa. It can also be said that the greater the distance on the scale between the item (difficulty) and the respondent (latent trait), the more certainty we can expect in estimating the respondent's response. When the distance is close to zero, the probability of a correct response is close to 50%.

The graphical representation of the response curve has the shape of an S (ogive or sigmoid) and is most commonly referred to as the item characteristic curve.

For the Rasch model, the item is at the inflection point of the curve. Simplistically, we can say that it is in the middle, or at the point of transition to the top of the S-curve, or at the point of change in the direction of the function. As the asymptotes are 0 and 1, the mid-point is 0.5. Therefore, in the Rasch model, the location of the item, its difficulty, is at the point where there is a 50% expectation of a correct answer.

We have stated that the item characteristic curve takes the form of an S. This implies that the probability of the respondent's correct response does not increase at a constant rate with a rightward shift in the scale, that is, as the level of the latent trait increases. There is a plateau effect at either end. Because this ogive shape is evident in cumulative or logistic distributions, one-parameter models, including Rasch, exploit this non-linearity. This is why the term one-parameter logistic models is used. These are the simplest models.

They are calculated using formula (1),

$$P(\theta, b) = \frac{e^{(\theta - b)}}{1 + e^{(\theta - b)}},$$

where $P(\theta, b)$ is the response probability, e is the constant 2.7183, and $(\theta - b)$ is the distance between the respondent and the item, where θ represents the latent trait parameter and b the difficulty parameter. Formula (1) thus represents the formula for calculating the Rasch model. This formula also indicates that the probability of answering item x is a function of the distance between the respondent and the item, which can theoretically take infinite values $(-\infty, +\infty)$. In general, items with negative values are described as easy, items with values around zero as moderate, and items with positive values as difficult. In practice, a range from −3 to +3 is then used.

2.4.1.6 Estimation of the Respondent's Position on the Scale (Latent Trait *θ*)

The respondent's position on the scale (the value of the latent trait θ) is often unknown, especially during the development of an assessment tool. The same is true for the item parameter δ, representing its difficulty. Logits are used as the units in which parameter values are reported.

A simplified logarithmic transformation of formula (1) is used to calculate the probability of a particular response pattern, and the probability is referred to as the log-likelihood function, which corresponds to the respondent's placement on the scale for a particular response pattern. This supports the assertion that for one-parameter models, the score obtained presents complete information for estimating the level of a respondent's latent trait (Čepička, 2002; de Ayala, 2009; Utesch et al., 2018; Warne et al., 2012). The values of the log-likelihood function are infinite when only right/wrong answers are given.

2.4.1.7 Standard Error of the Estimate and of the Information

Based on the data, we obtain the error of the statistical parameter estimate, known as the standard error. This is used as an index of the variability (e.g., standard deviation) of the estimate relative to the parameter estimate. The larger the value of the error, the less precise the value of the parameter we have obtained. In IRT, we can use the standard error of the estimate as a predictor of the precision of the respondent's parameter relative to its value on the scale. The standard error of estimate should not be confused with the standard error of measurement. The standard error of estimate is affected by the quality of the assessment tool item and by the length of the assessment tool. Adding similar items (by the value of their parameter) reduces the error. The standard error of estimate can be used to produce a limit for maximum likelihood estimation, as well as to produce a range of response pattern probabilities for a given latent trait. The smaller the likelihood range, the more information we have to estimate the respondent's position on the scale. In this way we can quantify the amount of information provided by the assessment tool items or the tool itself for estimating the latent trait parameter. This is the total information provided by the test.

Unlike the concept of reliability, which depends on both the assessment tool and the sample of respondents, the total information of the test depends on the instrument itself. This presents an overview of how much information the assessment tool provides to separate two different latent traits of respondents that are close to each other on the scale. The total information of the assessment tool shows that each item potentially contains some information useful for reducing inaccuracies about the respondent's parameter (i.e., latent trait) independently of the other items of the instrument. Because of this independence, we can sum the contributions of each item to the gain in total information of the assessment tool. The total information is thus the sum of the information of the individual items. The greatest item information gain in the Rasch model is at the point of the item parameter (i.e., difficulty). The information function is unimodal and symmetric with respect to the item parameter (de Ayala, 2009).

2.4.2 Estimation Capacity of the Tool

To determine the reliability of the model, it is necessary to assess the accuracy of the estimation of the item parameters and the latent trait. Maximum likelihood, goodness-of-fit, and information function methods are used.

Likelihood principles can then be employed to estimate the difficulty parameter, the position of the item on the scale. To find out how well the item and the assessment tool can estimate the latent trait, we need to test it and determine the total information of the assessment tool. The information contribution of the item and the assessment tool is a function of the respondent parameter (i.e., latent trait parameter). Using the inverse relationship between information gain and standard error of estimate, we observe a decrease in the information function as the standard error of estimate increases. We exploit this in constructing an assessment tool for subjects with different levels of the latent trait by adding and removing items at the ends of the scale (i.e., item difficulty continuum) to obtain information about respondents with higher or lower levels of the latent trait. In this way, we can create an instrument that measures a broad range of latent traits or, conversely, a very precise tool that assesses a specific level of the latent trait (Pilkonis et al., 2014).

We can also use a target total information function of the tool. For example, when we need to establish a point below which the latent trait values are unacceptable to us (insufficient for successful item completion), we set the target total information function to that value. The tool will then discriminate best around this point. The information function can also be used when testing a tool with specific characteristics. This ability is the advantage of having items and respondents on the same scale (de Ayala, 2009).

Furthermore, our ability to estimate the amount of information for the estimation of the respondent parameter is based solely on the estimation of the item parameter. However, it depends on a sufficiently large item bank and (un)constrained item selection to achieve validity given the purpose of the instrument.

Once the instrument is constructed, validity must be checked again (Chiesi et al., 2013).

From the above, it follows that the use of the Rasch model and the Guttman scale seems optimal for the development of an assessment tool and its subsequent use in practice.

2.4.3 Mokken Analysis

Mokken scaling techniques are a useful tool for developing and constructing unidimensional tests (Sijtsma et al., 2008). Stochl, Jones, and Croudance (2012) add that Mokken techniques can also be used to test the appropriateness of using Rasch analysis.

The main advantage of Mokken scaling techniques is that they do not require the assumption of non-linear behaviour of the response probability (Sijtsma & Molenaar, 2002).

Mokken scaling techniques use stochastic ordering to rank outcomes based on their characteristics. This nonparametric IRT (NIRT) method can also help to assess the dimensionality of a test and is more accurate than Cronbach's alpha for determining test reliability, especially when using the Rasch model. Like IRT models, Mokken techniques entail several assumptions that must be met. These include the assumptions of unidimensionality, local independence, monotonicity, non-intersectionality, and invariant item ordering (Stochl et al., 2012).

Compliance with the local independence assumption is required for many models, not only Mokken analysis, and has been explained above, but independence of responses relative to other responses in the test is required.

To assess whether the unidimensionality assumption is met, all items in the assessment tool measure a single construct. Loevinger's scaling coefficients *H* can be used to check this (Christensen et al., 2010). A rule of thumb is used for scoring. Values of $Hi < 0.3$ are unsatisfactory, or the scales are not considered unidimensional. Values of $Hi > 0.5$ are considered strong, that is, unidimensional (Ligtvoet et al., 2010; Sijtsma & Molenaar, 2002). The higher the *Hi* values, the better the items discriminate between the different levels of the respondent's latent trait (Sijtsma & van der Ark, 2001).

The monotonicity assumption is considered next. Characteristic curves of the items and monotonically increasing functions of the latent variable are examined. In practice, the monotonicity of item *i* is assessed by replacing the value of the latent trait by the rest score (i.e., the sum of responses to all items except item *i*) (Molenaar & Sijtsma, 2000).

Adherence to the assumption of non-intersection and invariant item ordering determines whether the characteristic curves of the items touch or, in extreme cases, match completely (Molenaar & Sijtsma, 2000). If the assumption is satisfied for dichotomously scored items, then the probability of a correct response must be higher for the simpler item, with no difference in the level of the latent trait of the respondents.

If these assumptions are met, Mokken analysis can be used as an additional approach to assess the appropriateness of using the Rasch model and to support the results and consistency of the assessment tool. Similarly, provided these assumptions, Mokken analysis can be used to estimate reliability.

The use of Mokken analysis appears to be a suitable means of developing an assessment tool for the evaluation of puck control skills in ice hockey.

3 SUMMARY OF THE THEORETICAL KNOWLEDGE AND THE RESEARCH PROBLEM

Ice hockey involves numerous skills, particularly in individual game activities. However, existing literature lacks consensus regarding the necessary competencies for ice hockey players, and in practice there is no shared opinion among experts about what exactly ice hockey players should know e.g., (Bukač, 2014; Girdauskas & Kazakevičius, 2018; Hoff, 2014; Mancini, 2015; Perič, 2002; Rausch & Brennan, 2014; Tabrum, 2009). Despite various recommendations, there is little scientific evidence to support their claims.

The testing of ice hockey players serves its purpose but primarily focuses on assessing physical fitness in practical settings. While scientifically grounded tests exist, their applicability to the specifics of ice hockey is debated among professionals. Moreover, evaluations predominantly occur in controlled laboratory conditions, with minimal skill assessment on the ice. Player evaluation primarily relies on coaches' and experts' observations during games and practices, thereby introducing evaluator bias. This bias stems from differences in evaluators' education, experience, preferences, current needs, and even moods. The absence of a scientifically validated assessment tool further exacerbates this issue, with no such tool found in Czech or international literature, or in methodological manuals and recommendations from hockey associations and federations. Based on preceding chapters and practical needs, the development of a scientifically based assessment tool for evaluating ice hockey players' skills is deemed necessary.

Requirements for developing such a tool must emphasise practicality and convenience, prioritising ease of use and applicability to a wide age range of players. It must also consider the laws of ontogeny, the sensitive period of skill development including endurance, speed, strength, coordination, and changes in body proportions. Additionally, the tool should accommodate the dynamics of motor learning stages and associated skill mastery levels. The individual items of the assessment tool must therefore take into account anatomical and physiological differences among players and differentiate skills along with degrees of their mastery.

It is also very difficult to find in the literature any substantial recommendations regarding the skills that players should have with respect to the length of time for which they have been playing the sport. Yet, identifying these skills is pivotal for effective training and player development, which should be based on specific feedback.

The problem, therefore, is to identify which skills a player should have mastered after varying lengths of training, as well as to determine the degree of mastery of these skills. Developing a suitable assessment tool capable of evaluating skills and establishing standards relative to training duration and players' ages would be advantageous.

A critical aspect in crafting the assessment tool is selecting the skills to be evaluated. Given the absence of any scientifically validated assessment tool for ice hockey skills in practice or literature, it is necessary to begin with fundamental skills. One such fundamental skill, initiated at the outset of training and typically reaching a quality level corresponding to the third stage of motor learning by around 15 years of age, is puck control (Fait et al., 2011; Girdauskas & Kazakevičius, 2018; Stark et al., 2009; Wiseman et al., 2014; Hockey Canada, 2018; USA Hockey, 2024). Furthermore, assessing this skill allows for relatively straightforward determination whether a task has been completed or not. To provide these subtasks, we draw from literature, expert practitioner knowledge, as well as Rasch analysis and the Guttman scale.

Hence, the challenge is to develop an assessment tool for evaluating the skill of puck control for players aged 6–15 years. Consequently, the initial phase of the research will focus on creating a scale for assessing ice hockey skill – puck control.

Once the tool is created, it will also be necessary to establish puck control standards in the Czech Republic. In the second stage of the research, we will employ the created scale to define puck control standards in ice hockey relative to players' ages. These defined standards, coupled with the assessment tool, will aid coaches in individual youth categories to gauge the efficacy of training activities and the rate of puck control skill development based on scientifically grounded feedback. Moreover, the defined standards will enhance result interpretation, providing coaches and players immediate feedback on puck control training.

4 METHODOLOGY

The methodological section will be structured around the objectives of our theoretical-empirical work concerning the creation of an assessment tool for ice hockey players and the subsequent establishment of standards.

The research will be divided into three phases:

- Stage zero
  - A systematic literature review – this phase will involve conducting a literature research to verify the absence of a diagnostic tool in ice hockey.
- First stage
  - Development of an assessment tool for ice hockey players – drawing from the literature review and interviews with ice hockey experts, we will compile an item bank to construct an assessment tool for evaluating an individual's ice hockey performance.
  - Validation of assessment tool items – following the calibration[2] of items from the item bank and Rasch analysis, item selection[3] will be carried out, the properties of the scale will be assessed, and the items will be ranked to form a Guttman scale.
- Second stage
  - Testing – using the developed assessment tool, players will undergo testing to collect data for establishing standards regarding puck control in ice hockey.
  - Definition of puck control standards – following from the analysis of the data from the tests conducted, standards of skills in ice hockey will be formulated.

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[2] For the purpose of our work, we use the term item calibration to refer to the collection of data for subsequent analysis (verification) of items using Rasch and Mokken analysis. Following from the item calibration and the results of the analysis, item selection will be conducted (see under "Selection" for more details).

[3] After item calibration and analysis of the collected data, item selection will be carried out. In each round of selection, all items are evaluated based on the data obtained, and items that do not fit the Rasch model are removed from the item bank. In each subsequent round of selection, only the remaining items are analysed using the same key as in the first round.

4.1 Aims and Tasks

The objectives of the thesis are outlined as follows:

- The first aim of the thesis is to develop a tool to assess an individual's ice hockey skills – drawing from the available literature and recommendations from expert practitioners in the field of ice hockey, a scale comprising approximately 20 items will be created for the assessment tool. This scale will encompass the puck control skills deemed necessary for players across various age groups.
- The second aim of the thesis is to utilise the developed assessment tool to establish standards pertaining to puck control among ice hockey players. Through player testing, it will be determined what skills players should possess with respect to their age.

To accomplish the aims of the dissertation, the following tasks are required:

- A systematic literature review – in the initial "zero stage" of the research, a two-stage research formula will be created, where two or three variants of keywords will be used for literature research to facilitate a comprehensive analysis. Utilising the selected research formula, a literature analysis will be conducted to verify the absence of an assessment tool to evaluate ice hockey skills, specifically, puck control.
- Selection of puck control drills – based on the literature review and methodological recommendations, appropriate puck control drills will be selected for assessment. Items for the diagnostic tool will be designed based on literature findings and subsequently reviewed and refined by expert practitioners in ice hockey.
- Selection of experts for scoring – ice hockey experts holding at least a "B" licence and currently coaching the relevant age group will be chosen to evaluate whether specific criteria for item fulfilment have been met.
- Selection of test participants – participants will be selected according to both their calendar and their sporting age. Test participants must meet both criteria, and their sporting age must not have been interrupted or affected in any way in relation to other participants (interruption of regular training activities, except for common illnesses). Participants will undergo training doses

consistent with recommendations outlined in Czech Hockey methodological materials for their respective age groups.

- Preparation of the research schedule, including item calibration, item verification, and main testing – since the research is divided into two stages, the research schedule will reflect this division. The first, qualitative stage will focus on calibrating and verifying the assessment tool items. The second, quantitative stage will involve administering tests and defining standards of puck control in ice hockey.

4.2 Research Questions

Given the two aims of the thesis, it is appropriate to formulate the research question in two parts.

- The first question is: Which puck control skills should ice hockey players have mastered by the age of fifteen?
- The second question is: What are the standards of puck control in each age category of ice hockey?

4.3 Hypotheses

The hypotheses are formulated as follows:

- H1: The most difficult item will not fit the selected model in the developed assessment tool.
- H2: The second most difficult item will not fit the selected model in the developed assessment tool.

4.4 Research Design

As previously mentioned, the research will be divided into two stages, the first and the second, preceded by the zero stage. In the zero stage, the absence of a similar assessment tool or its development will be verified through a literature review. The first stage will entail the development of an assessment tool to evaluate puck control skills in ice hockey. In the second stage, the developed tool will be utilised to establish standards for puck control in ice hockey among players aged 6–15 in the Czech Republic. The research design for these stages will be defined accordingly. For convenience and ease of overview, a diagram of the research design is provided in Figure 1.

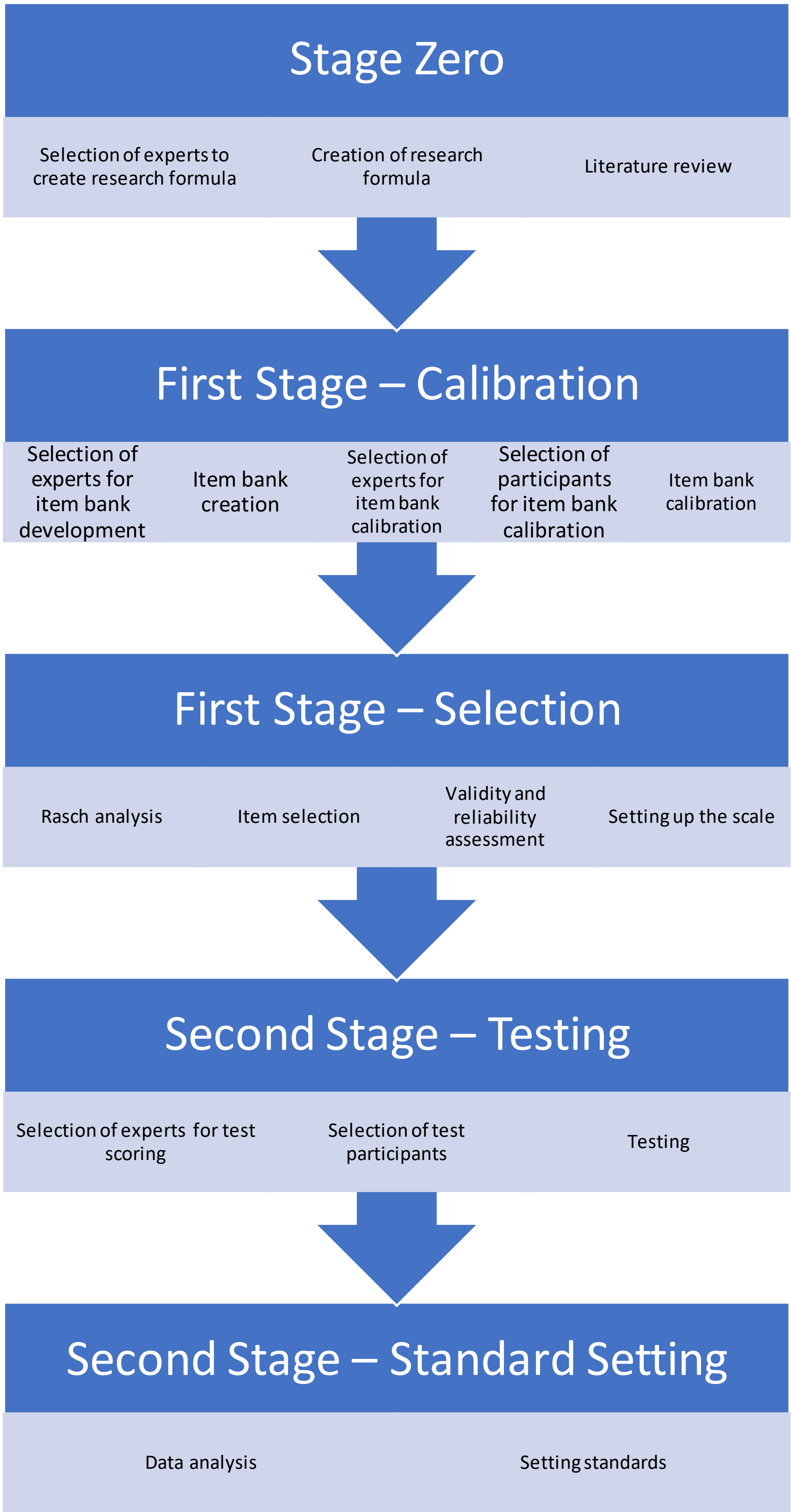

Figure 1 – Research design

4.4.1 Stage Zero

In the zero phase of the research, a team of four to five experts in the field of ice hockey will be selected to assist in the development of the research formula to conduct a systematic review of the literature. The crafting of the research formula will be a two-stage process where two or three keyword variations will be created and presented to the experts for review. Following a period of approximately two weeks, the experts will be revisited, the variants will be further consulted, and the final research formula will be selected. Based on the selected research formula, a systematic literature review will be carried out. To qualify as experts in the field of ice hockey for research formula development, candidates must possess a Master's degree, hold a valid "A" licence, and possess a minimum of ten years' experience as a player or coach. This phase aims to comprehensively explore existing literature on assessment tools in ice hockey, facilitating the development of an item bank for the assessment tool.

Building upon the established research formula, a systematic review of literature will be conducted using the Web of Science and SPORTDiscus databases. A thorough analysis of literature will be conducted to ascertain the existence of an assessment tool specifically designed for evaluating puck control in ice hockey.

4.4.2 Stage One

The initial phase of the research will concentrate on crafting an assessment tool tailored for ice hockey players. A scale will be devised to evaluate an individual player's puck control skills in ice hockey. The items will be validated, modified accordingly, and the scale will be constructed.

4.4.2.1 Creating the Assessment Tool – Calibration

The calibration of assessment tool items will be divided into the following steps:

- Selection of expert "makers" to create the item bank of the assessment tool – in order to create the items of the assessment tool, it will be necessary to draw not only on the literature but also on the practice and knowledge of expert "makers" in the field of ice hockey. The experts must hold a valid "A" licence and have at least ten years of experience as coaches or players. Four to five experts will be selected.
- Creation of the item bank (60–100 items) – individual items for the assessment tool will be selected based on literature findings and recommendations from the expert "makers" who will be interviewed. During these interviews, the

experts will provide input on the items and will be able to propose additional ones. The creation of the item bank and expert interviews will take place in two stages. Approximately two weeks after the first meeting, the experts will be consulted again and a second stage of interviews will take place. Subsequently, items will be selected for inclusion in the item bank of the assessment tool.

- Selection of expert “calibration raters” for item calibration and briefing of experts – expert “calibration raters” holding at least a “B” licence and currently coaching in the relevant age group will be chosen to evaluate participants for item calibration. Each participant will be scored by the expert “calibration rater” on a yes/no (pass/fail) scale. Each expert “calibration rater” will be briefed on item performance and conditions prior to the calibration. Each participant will be assessed simultaneously by two expert “calibration raters”, whose evaluation must match. Approximately 32 expert “calibration raters” will be selected.
- Selection of participants for calibration of diagnostic tool items – an equal number of participants will be selected for each age group to undergo item calibration (approximately 100–200 subjects in total). Before the calibration of each item, participants will receive instructions and a demonstration illustrating a successful performance or failure of the item.
- Calibration of the assessment tool items – once the expert “calibration raters” are briefed and the participants receive instructions, the calibration of each item of the assessment tool is carried out.

4.4.2.2 Item Verification – Selection

In the substage of item verification and selection, items are selected from the item bank for inclusion in the assessment tool based on data analysis. This process will consist of multiple rounds, each following the same procedure. Once all items conform to the selected model, the diagnostic tool is created. For ease of overview and clarity, a simple diagram is provided in Figure 2.[4]

[4] The diagram does not show the actual number of rounds of selection of items from the item bank, it is only intended to present the general idea of the process of creating the assessment tool, for convenience and clarity.

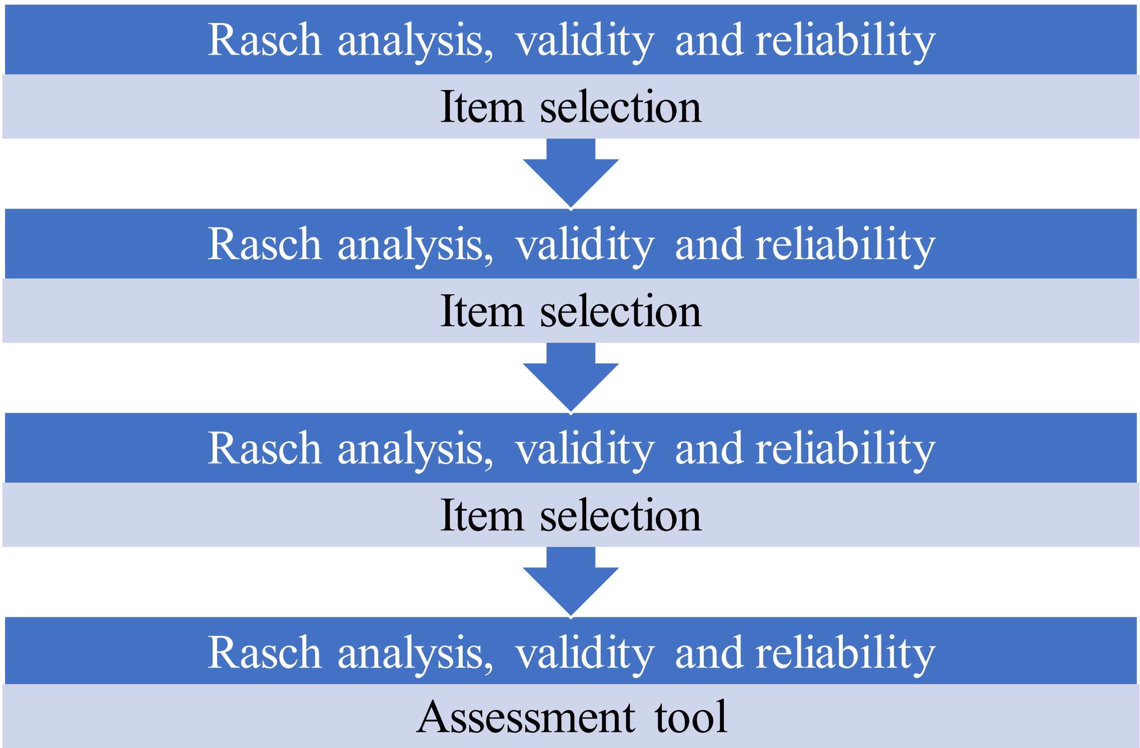

Figure 2 – Item verification and selection

- Rasch analysis and validation of assessment tool items – following the calibration of assessment tool items, the data will be collected, analysed using Rasch analysis, and statistically evaluated.
- Selection of items – based on the analysed data, individual items will be either removed from the item bank or retained for further analysis.
- Scale validity and reliability assessment – the properties of the scale, including its authenticity, will be assessed.
- Setting up the scale – a Guttman-type scale will be constructed based on the calculated difficulty of each item.

4.4.3 Stage Two

The quantitative phase of the research will concentrate on establishing standards in ice hockey pertaining to puck control. Tests will be conducted to gather data, based on which standards will be defined for each age group.

4.4.3.1 Testing

The substage of testing will include the following steps:

- Selection of expert “test raters” for test scoring – expert “test raters” will be selected for test evaluation under the same conditions as for item calibration. Approximately 48 expert “test raters” will be selected.
- Selection of participants for testing – for testing, each age group will have the same number of participants, but the overall number of participants will be increased to obtain a large sample size (200–400 participants). Prior to testing each item, the participants will receive instructions and a demonstration illustrating a successful completion or a failure to complete the item.
- Conducting the test – after briefing the expert “test raters” and instructing the participants, the test will be carried out.

4.4.3.2 Setting Standards

The substage of standard setting will include the following tasks:

- Analysis of test data – the data obtained from the tests will undergo statistical processing.
- Setting standards – standards for puck control in ice hockey will be established.

4.5 Research Set

For our research, it will be necessary to assemble a group of expert “makers” to help in creating the assessment tool, a group of expert “evaluators”, and a set of participants for both calibration and testing.

4.5.1 Experts

For stage zero of the research, four to five experts from the field of ice hockey will be recruited to develop the research formula for the systematic review. Each expert is required to have a university degree (at least a Master’s degree), a valid “A” coaching licence, and at least ten years of experience as a player or coach.

Four to five expert “creators” with a valid “A” licence and at least ten years’ experience as methodologists, coaches, or players will be selected to formulate the items for the item bank intended for the assessment tool. With their help, the item bank will be created based on interviews and literature findings.

Approximately 80 expert “raters” will be selected to assess the participants. The expert raters must have a valid coaching licence (at least “B”) and must be currently coaching the age group that they are assessing. Each participant will be evaluated by the experts on a yes/no (pass/fail) scale. Prior to calibration and testing, the expert "assessor" will be instructed on the performance and conditions for passing the item, along with indications of failure, if any. Each participant will always be assessed simultaneously by two expert assessors, and for a valid test result, their assessment must align.

4.5.2 Participants

Participants (400–600) will be selected based on both their calendar and athletic age.[5] The participants must meet both criteria, with the athletic age remaining uninterrupted and unaffected in any way in relation to other participants (i.e., no interruption of continuous training activity, except for common illnesses). The subjects must undergo training doses (length and number of training sessions per week, training load) according to the recommendations outlined in the methodological materials of the Czech Ice Hockey Association for their respective age groups. Subjects will be selected exclusively from clubs covering all youth categories up to U15. Accordingly, the participants will be aged between 6 and 15 years. This selection aligns with methodological recommendations, which suggest organised training commencement by the end of preschool or the beginning of school age at the latest, with skills to be acquired at the level of the third phase of motor learning by the end of school age (i.e., 15 years).

4.5.3 Statistical Methods

An assessment tool will be developed to test selected participants. The Guttman scale and Rasch analysis will be employed to create an assessment tool for diagnosing ice hockey players in terms of puck control abilities. Validity and reliability of the scale will be assessed and item difficulty will be calculated. Content validity will be determined and reliability will be assessed using Cronbach's alpha and Mokken analysis.

4.6 Discussion of Methodology

Our methodology draws from literature, methodological recommendations, and practical insights. As previously mentioned, player skill assessment typically relies on match observations, leading to an overall evaluation of the player with individual skills

[5] Athletic age is the length of time for which individuals have been taking training doses and dedicating themselves to a particular sport speciality. This can vary between children of the same calendar age. For example, when a 7-year-old player started skating and playing hockey at the age of 3, he has an athletic age of 4. In contrast, another 7-year-old player, who started at the age of 5, has an athletic age of 2 years. The differences in skills can therefore be significant, especially for younger children.

described separately. This approach is in line with the methodological recommendations provided by various national ice hockey federations and associations, where skill development is reported independently, with only the individual's age being considered. The same approach is used in our work, where only the skill of puck control is assessed, while other skills are not taken into account. While skills like skating, shooting, or passing may influence puck control mastery, we presume that certain prerequisites for ice movement and skill progression exist for a given age group. However, these prerequisites are not explicitly addressed in training or skill mastery in practice or literature; instead, they are presumed to be automatic (Český hokej, 2018; Hockey Canada, 2018; USA Hockey, 2024).

In practice, the mastery of adequate prerequisites for movement on the ice and possibly other skills is regarded as a matter of course, and these related skills are not assessed or considered in any way during their acquisition and subsequent performance. Hypothetically, a player may master stickhandling off the ice. However, if the player is unable to even stand on the ice, which is automatically presumed, then the assessment of the player's ability to stickhandle while standing still is negative for the purpose of evaluating the player because of the lack of mastery of the puck control skill, not because of the lack of mastery of the fundamentals of skating. In the development of our assessment tool and in the subsequent assessment of the participants, as in the existing literature and in practice, the necessary prerequisites are disregarded and only the puck control skill is considered relevant.

Furthermore, environmental factors like ice condition, which can significantly affect puck control skills, are not considered when assessing players or setting standards. The literature recommends well-prepared ice surfaces for skill acquisition and practice, and the same is expected in practical settings. During games, it is not uncommon to hear complaints concerning a poor quality of ice, but at any given time, the ice is the same for both opponents. However, when testing on ice, only one player or team is present, and their performance is affected by the quality of the ice. For the purpose of our work, as well as for the subsequent use of the developed assessment tool, we follow recommendations offered both by the literature and by practical experience, where a clean and renewed ice surface is recommended for training.

During the testing, when an unevenness or other defect of the ice surface had been found, the test was moved to another part of the rink where the ice was in good condition. Such a recommendation was also given for the use of the assessment tool in clubs in practice, given the small space requirement of the developed assessment tool. Therefore, once the ice surface was properly cleaned and renewed, the items were calibrated, and the participants tested, the issue of ice surface quality was not addressed further, assuming that the players performed the items without any negative effect of the ice surface on their performance. For the use of the developed assessment tool in practice, it should be noted that thanks to the small space requirements and the option of moving the test to another part of the ice rink, it is possible to gradually diagnose the whole club (considering the usual number of players in clubs in the Czech Republic) without cleaning or renewing the ice surface and losing time.

The selection of participants was carried out according to a predetermined methodology. To be included in the study, participants had to meet specific conditions for participation in training and matches, based on the Czech Ice Hockey Association's methodological materials. These criteria were always confirmed with the coach of each club's respective category before selecting the players, whether for item bank calibration or data collection for defining standards. No attendance records or other documents were required as proof of compliance with the established rules. We deemed this procedure sufficient for our research purposes, and no issues arose in practice regarding participant selection.

In addition to participant selection, rules were defined for selecting experts to act as assessment tool developers and raters. We found that educational background and acquired licences were not essential for the outcomes of our work, while practical experience (playing or coaching) was more beneficial for the purpose of developing the assessment tool. For the expert raters, clear explanation, understanding, and where applicable, demonstration of correct and incorrect performances or potential errors leading to a fail/no/0 rating proved essential. This aspect is also essential for the future application of the developed assessment tool in practice. Throughout our research, and due to the criteria set for expert selection and subsequent participant assessment, we encountered no issues. Experts were properly instructed after their selection, and they were encouraged to seek clarification if uncertain. Furthermore, raters were required to reach a consensus on a player's rating; and in rare instances of disagreement, the rating was considered negative. The criteria set for the selection of the raters, as well as for the rating process itself, proved sufficient and can be recommended for further work of a similar nature, with an emphasis on proper instruction of the raters.

Regarding the data collection process, the developed assessment tool includes a detailed description of correct and incorrect performances (including potential errors) for practical application. This description was informed by questions raised by experts during the item bank calibration and data collection for the definition of standards.

5 RESULTS

5.1 Systematic Review

In the zero phase of the research, we aimed to verify our assumption learnt from practical experience that there existed no published or even informally disseminated methodological recommendations from international associations and federations for a standardised test to assess ice hockey skills in general or the skill of puck control in particular.

To begin with, keywords ("ice hockey, test, development, skills, puck control") were proposed. In collaboration with the selected experts, keyword variations were created for our research formula. In the first round of research formula variant creation, three keyword variants were generated.

In the second round, approximately two weeks later, one variant of the research formula was selected, which was "ice hockey, test, development, skills". Using this research formula, the Web of Science and SPORTDiscus databases were searched, yielding approximately 10,000 results.

Most literature on ice hockey focuses on health complications, including injuries, injury recovery, and injury elimination; for example: Reed, Keightley, Taha, and Greenwald (2017); Simmons-MacMhathan, Swedler, and Kerr (2017); and Wolfinger and Davenport (2016). Another frequent focus is physical fitness testing; for example: Haukali and Tjelta (2016); Kutáč, Sigmund, and Botek (2017); and Šiška and Kováčiková (2017).

Hence, after an initial selection process, the pool of articles was narrowed down to approximately 45 papers that showed at least some minimal connection to our topic.

Subsequently, after the second selection, only seven articles were selected that were at least partially related to the assessment of ice hockey skills (Beckman et al., 2007; Fait et al., 2011; Forsman et al., 2016; Girdauskas & Kazakevičius, 2018; Gotwals et al., 2010; Stark et al., 2009; Wiseman et al., 2014). However, none of these articles specifically address the development of an assessment tool to evaluate hockey skills, the assessment of puck control skills, and the definition of standards.

Our systematic literature review therefore confirmed that no standardised assessment tool was available to assess the ice hockey skill relevant to our research; that is, puck control. This corroborated our initial assumption based on practical experience that standardised tests of ice hockey skills were lacking in the literature.

5.2 Developing the Item Bank and Verifying Items

To create the item bank for the assessment tool, it was necessary to draw not only on the literature but also on practical experience and knowledge of expert "makers" in the field of ice hockey. Following the literature review, an item bank of approximately 100 items was created. Five selected expert "makers" were then approached, asked to comment on the items, and suggest additional ones. This process involved initial familiarisation with the items and discussion of the items created, providing feedback, and suggesting new items. After a break of about two weeks, during which the experts had the opportunity to further reflect on the items, modify them, and prepare others, they were contacted again and given the opportunity to express final comments. The item bank was then finalised, encompassing a scale of 74 dichotomous/binary items.[6]

Once the item bank was finished, the items were calibrated. Expert raters and participants were selected and the items were calibrated. A total of 357 participants were selected for calibration and all 74 items[7] were tested. The original intention was to obtain 100–200 participants for the calibration. Despite the difficulty of the process, we managed to test a larger number of participants than the original estimate. The participants were rated on a yes/no (pass/fail) scale, and their results were then processed and prepared for item validation.

Once the item bank items had been calibrated, the data were collected, analysed, and scored using Rasch analysis. For all calculations and selections, the value of the discriminant parameter was fixed at exactly 1.00 to adhere to the Rasch model. This fixing resulted in anomalies in the calculations of the standard error of the test and test

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[6] Henceforth only the numerical designation of the item will be used, without further reference to the full verbal name or explanation of the content or principle of the item. The naming, as well as correct and incorrect designations of items are given in the Appendices. The numerical designation of the items is random and has no influence on the difficulty or the order of the items during their execution. The numerical codes have been introduced mostly for an immediate control over the number of items and their easy identification during the research. In practice, in the assessment tool that has been created, the numbers no longer serve to describe the items but to indicate the order in which the items must be administered to the players in order to assess the player's latent trait.

[7] A list of all the items can be found in Appendix 4 – Items.

information, which is discussed in the final version of the assessment tool. However, in all selection rounds, these anomalies were addressed using Mokken analysis.

Using the statistical software R and its packages, the values defining the Rasch model were calculated. Non-fitting items were removed, and the remaining items were recalculated until they reached appropriate values for the Rasch model. The data in R were calculated using two approaches to validate them. First, the marginal maximum likelihood approach was employed, where the model is defined based on the assumption of a standard normal distribution of the latent trait (person parameter). Second, the conditional maximum likelihood approach was applied, which is used for the Rasch model and binary scored items when the normal distribution is violated (Baetschmann et al., 2015).

The slightly different values (and vice versa, where item difficulty or simplicity is calculated) are caused by the different approaches to the calculations. However, these minor differences in the numbers do not affect the practical use of the tool. When the data are arranged in the form of a Guttman scale, it is the number of items completed by a given player that is important, not the difficulty of the item (e.g., when a player completes only two items, he is at the beginning of his skill acquisition process; conversely, if he reaches the last item of the test, his skill can be described as “mastery”). The value expressed in logits is irrelevant in practice.

Because of the large number of items and the nature of the tables and figures used during the selection rounds, only the tables and figures essential for the selection of the items for the developed assessment tool are retained in the text of the thesis, while the others are included along with comments in the Appendices. Tables and figures necessary for the developed assessment tool are all included.

5.3 First Selection Round

In the first round, all 74 items were analysed based on data collected from 357 participants. The value of the discriminant parameter was set and fixed at exactly 1.00 for the calculations (the value for the Rasch model). The difficulty values of each item were calculated and ranged from −6.05 logits for the easiest item (item 13) to 3.61 logits for the most difficult one (item 61). Standard errors of estimation (SE) were also calculated for each item. The item difficulty scores and standard errors of estimate for all items are shown in Appendix 5 – Item Difficulty, Standard Error, Round 1.

Using the approach of conditional maximum likelihood, the item difficulty values ranged from 4.91 logits for item 13 to −4.96 logits for item 61. The slightly different values are due to the different calculation approach, as mentioned above. Because the calculation is done as the "simplicity" of the items, the values are reversed, with the simplest items being positive. The values for the standard error of the estimate and the lower and upper confidence intervals have also been calculated. All values are shown in Appendix 6 – Item Difficulty, Conditional Maximum Likelihood, Round 1.

The goodness of fit of the model was then tested using Pearson's chi-square. Its value was $p = 0.16$. Although the model does not fit the data according to the calculated value, we follow the logic of the Rasch model in the development of the assessment tool. If the model does not fit the data, the model is not changed when creating the assessment tool, but rather the items that do not fit the model are removed from the item bank.

The descriptive statistics of the model were evaluated, and 84.83% of the items were in the {−4, 4} logits interval, corresponding to approximately 62 items out of 74.

Item fit and person fit were calculated. Plots of item characteristic curves showing the dependence of the probability of a correct response on the participant's latent trait (Appendix 7 – Plotted Item Characteristic Curves, Round 1) and item information curves showing the information contribution of the item as a function of the participant's latent trait (Appendix 8 – Plotted Item Information Curves, Round 1) were generated. A plot of the test information function and standard error was also generated (Appendix 9 – Plotted Test Information Function, Round 1), with higher values of standard error corresponding to the first selection rounds. Reliability was calculated using Cronbach's alpha, which was 0.971, and the confidence interval was {0.967; 0.975}.

The individual items and the test as a whole were also analysed using Mokken analysis methods. First, the unidimensionality of the scale was analysed and assessed. All 74 items had H-values in a range of H = {0,803–0,213}. The whole test then had a coefficient of $H = 0.513$ with a standard error of 0.019. Using Mokken analysis, it was found that there were items in our item bank with low unidimensionality stability and even items that did not fit the test due to their very low unidimensionality stability. The item scores are shown in Appendix 10 – Unidimensionality, Round 1.

The monotonicity of the items was also assessed, with only item 26 showing a violation, but this was not significant. The scores are presented in Appendix 11 – Monotonicity, Round 1.

To assess reliability using Mokken analysis, the invariant item ordering must be assessed. Violations were recorded here and are presented in Appendix 12 – Invariant Item Ordering, Round 1. The value of H was then 0.497. Despite these violations of the reliability assessment assumptions, the reliability was calculated as rho = 0.975.

A map of the distribution of items and subjects on the scale was also produced (Appendix 13 – Person-Item Map, Round 1). The map shows the distribution of item difficulty, where we tried to include as wide a range of difficulty as possible when creating the item bank. Depending on the difficulty of the items, the distribution of the level of the latent trait (the skill of puck control) in the participant pool including players aged 6–15 years is also shown. Appendix 14 – Person-Item Map Sorted, Round 1 shows the same distribution of items and subjects but sorted by difficulty from easiest to hardest.

Finally, the values of the outfit and infit statistics were calculated and used to select the items. Chi-square values, degrees of freedom, and significance level were calculated, as well as outfit and infit mean square and outfit and infit t-statistics.

Selection was made based on the outfit and infit mean square, with values of 0.5–1.5 being appropriate for the development of an assessment tool. Values above 1.5 are unproductive. Although values below 0.5 are only less productive for diagnostic tool development (Linacre, 2002), items with outfit mean square values below 0.5 were also excluded from the item bank, with two exceptions. Given the difficulty of items 60 and 61 (the two most difficult items) and the assumption that they would be included in the final diagnostic tool in the future, these two items were retained in the item bank. In addition, their outfit scores were just below the 0.5 threshold. The low scores can be attributed to the high difficulty of the items, with only a small percentage of participants managing to complete them. For the final assessment tool, however, these two items will be very useful in assessing players, especially those aged 14–15.

In the first round of the section, items 8, 13, 14, 17, 21, 22, 25, 28, 29, 32, 33, 35, 45, 46, 47, 48, 51, 57, 58, 59, 64, 69, and 73 were removed from the item bank. Thus, a total of 23 items were removed from the item bank after the first round. For the second round of selection, 51 items remained in the item bank. All absolute fit values are shown in Table 1 – Absolute Fit: Round 1. The table indicates in bold and colour those items that were eliminated in the first round of selection because their values did not fit within the 0.5–1.5 outfit and infit mean square interval. For example, item 22 with a value of 4.675 or item 73 with a value of 0.258 were eliminated.

```
##             Chisq  df p-value Outfit MSQ Infit MSQ Outfit t Infit t
## Item.1  522.909 355   0.000      1.469     1.168     0.74    0.89
## Item.2  293.961 355   0.992      0.826     1.110    -0.40    1.25
## Item.3  224.430 355   1.000      0.630     0.860    -1.12   -1.67
## Item.4  387.385 355   0.114      1.088     1.024     0.35    0.30
## Item.5  365.967 355   0.333      1.028     0.966     0.26   -0.25
## Item.6  247.893 355   1.000      0.696     0.936    -1.52   -0.80
## Item.7  221.727 355   1.000      0.623     0.754    -1.93   -3.36
## Item.8  597.449 355   0.000      1.678     0.999     2.61    0.02
## Item.9  214.647 355   1.000      0.603     0.729    -1.58   -3.59
## Item.10 200.416 355   1.000      0.563     0.743    -2.94   -3.84
## Item.11 194.413 355   1.000      0.546     0.711    -2.88   -4.23
## Item.12 238.257 355   1.000      0.669     0.805    -1.96   -2.73
## Item.13 591.037 355   0.000      1.660     0.823     1.20   -0.20
## Item.14 738.829 355   0.000      2.075     0.864     1.05   -0.46
## Item.15 309.513 355   0.961      0.869     0.975    -0.15   -0.23
## Item.16 202.564 355   1.000      0.569     0.913    -1.26   -1.00
## Item.17 726.917 355   0.000      2.042     0.872     1.05   -0.49
## Item.18 496.953 355   0.000      1.396     0.996     0.70    0.02
## Item.19 281.479 355   0.998      0.791     0.977    -0.66   -0.25
## Item.20 243.426 355   1.000      0.684     0.805    -1.96   -2.81
## Item.211082.518 355   0.000      3.041     0.859     1.57   -0.64
## Item.221664.235 355   0.000      4.675     1.301     3.39    2.35
## Item.23 293.700 355   0.992      0.825     0.930    -0.74   -0.87
## Item.24 288.054 355   0.996      0.809     1.023    -0.41    0.29
## Item.25 573.081 355   0.000      1.610     1.091     0.91    0.65
## Item.26 470.404 355   0.000      1.321     1.415     1.16    5.21
## Item.27 515.419 355   0.000      1.448     1.254     1.94    3.00
## Item.28 674.686 355   0.000      1.895     1.080     1.37    0.71
## Item.29 878.042 355   0.000      2.466     1.342     4.23    3.80
## Item.30 520.131 355   0.000      1.461     1.150     1.04    1.54
## Item.31 400.693 355   0.047      1.126     1.071     0.67    0.92
## Item.32 605.211 355   0.000      1.700     1.102     1.54    1.12
## Item.33 563.317 355   0.000      1.582     1.203     1.76    2.30
## Item.34 464.223 355   0.000      1.304     1.168     0.80    1.77
## Item.35 645.820 355   0.000      1.814     1.232     3.45    2.82
## Item.36 317.490 355   0.924      0.892     0.951    -0.16   -0.54
## Item.37 503.234 355   0.000      1.414     1.024     2.04    0.34
## Item.38 208.285 355   1.000      0.585     0.711    -2.84   -4.64
## Item.39 221.897 355   1.000      0.623     0.797    -2.17   -3.30
## Item.40 206.113 355   1.000      0.579     0.785    -1.89   -3.34
## Item.41 409.915 355   0.023      1.151     1.112     0.62    1.34
## Item.42 202.850 355   1.000      0.570     1.152    -0.04    0.74
## Item.43 244.777 355   1.000      0.688     1.064    -0.84    0.75
## Item.44 294.007 355   0.992      0.826     1.007    -0.57    0.11
## Item.45 152.638 355   1.000      0.429     0.731    -1.81   -3.33
## Item.46 152.154 355   1.000      0.427     0.685    -2.54   -4.24
## Item.47 163.344 355   1.000      0.459     0.637    -3.00   -5.21
## Item.48 131.390 355   1.000      0.369     0.552    -3.69   -6.69
## Item.49 185.914 355   1.000      0.522     0.645    -2.70   -5.13
## Item.50 190.941 355   1.000      0.536     0.703    -2.10   -4.01
## Item.51 638.671 355   0.000      1.794     1.194     2.39    2.22
## Item.52 253.692 355   1.000      0.713     0.809    -1.13   -2.45
## Item.53 289.097 355   0.996      0.812     0.926    -0.79   -0.91
```

```
## Item.54 417.134 355   0.013        1.172      1.152      0.91    1.90
## Item.55 409.094 355   0.025        1.149      1.106      0.80    1.36
## Item.56 422.267 355   0.008        1.186      1.171      1.08    2.43
## Item.57 595.323 355   0.000        1.672      1.101      2.82    1.28
## Item.58 727.629 355   0.000        2.044      1.336      2.74    3.63
## Item.591051.162 355   0.000        2.953      1.387      5.49    4.28
## Item.60 156.274 355   1.000        0.439      0.776     -1.13   -2.37
## Item.61 177.680 355   1.000        0.499      0.825     -0.54   -1.43
## Item.62 207.854 355   1.000        0.584      0.785     -2.83   -3.38
## Item.63 308.172 355   0.965        0.866      0.915     -0.72   -1.29
## Item.64 598.748 355   0.000        1.682      1.463      3.13    5.39
## Item.65 289.539 355   0.995        0.813      0.898     -1.06   -1.56
## Item.66 314.126 355   0.942        0.882      0.947     -0.59   -0.80
## Item.67 298.479 355   0.987        0.838      0.918     -0.75   -1.25
## Item.68 265.176 355   1.000        0.745      0.945     -1.10   -0.80
## Item.69 783.718 355   0.000        2.201      1.264      2.25    2.68
## Item.70 360.933 355   0.403        1.014      1.088      0.14    1.11
## Item.71 218.629 355   1.000        0.614      0.860     -1.53   -2.04
## Item.72 266.283 355   1.000        0.748      0.937     -0.89   -0.74
## Item.73  91.997 355   1.000        0.258      0.862     -0.59   -0.63
## Item.74 232.491 355   1.000        0.653      0.892     -0.38   -0.87
```

Table 1 Absolute Fit: Round 1 (chisq – chi-square; df – degree of freedom; MSQ – mean square)

5.4 Second Selection Round

In the second round, 51 items were analysed in the same way as in the first round, based on data from 357 subjects. Difficulty scores were calculated for each item, ranging from −4.28 logits for the easiest item (item 42) to 3.2 logits for the most difficult item (item 61). Standard errors of estimation were also calculated for each item. The item difficulty scores and standard errors of estimates for all 51 items are given in Appendix 15 – Item Difficulty, Standard Error, Round 2.

Using conditional maximum likelihood, the item difficulty values ranged from 3.57 logits for item 42 to −4.8 logits for item 61. Again, the calculation is done as the "simplicity" of the items, with positive and negative values reversed when compared to the marginal maximum likelihood approach, where the simplest items are positive. The standard error of the estimate and the lower and upper confidence intervals were also calculated. All values are shown in Appendix 16 – Item Difficulty, Conditional Maximum Likelihood, Round 2.

The goodness of fit of the model was tested using Pearson's chi-square. Its value was $p = 0.98$. In the second round, according to the calculated value, the data fit the model.

The descriptive statistics of the model were evaluated and 88.32% of the items were within the {−4, 4} logits interval, corresponding to 45 items out of 51.

Again, item and person fit were calculated. Plots of item characteristic curves (Appendix 17 – Plotted Item Characteristic Curves, Round 2) and item information curves (Appendix 18 – Plotted Item Information Curves, Round 2) were generated. Appendix 19 – Plotted Test Information Function, Round 2 shows the information function of a test with 51 items and the standard error, manifesting an increasing standard error due to the selection process of items in the assessment tool. However, there is also a decrease in the information function of the test caused by the "fixing" of the value of the discriminant parameter. This anomaly is explained and described in section 5.11, which describes the developed assessment tool in detail. The reliability verified by Cronbach's alpha was 0.965, the confidence interval was {0.960; 0.970}.

For the Mokken analysis, the unidimensionality values for individual items were H = {0,828–0,404} and for the whole test H = 0.567, with a standard error of 0.019. There are still some items in the test that show moderate stability of unidimensionality. The values for each item are shown in Appendix 20 – Unidimensionality, Round 2.

The assessment of item monotonicity did not reveal any violations, as shown in Appendix 21 – Monotonicity, Round 2.

Also in the second round of selection, violations of invariant item ordering were found for some items. The values for all items are shown in Appendix 22 – Invariant Item Ordering, Round 2. Despite these violations of the assumptions, reliability was calculated using Mokken analysis with rho = 0.969.

A person-item map was produced (Appendix 23 – Person-Item Map, Round 2), which shows that the distribution of item difficulty still covers the full range of difficulty. The items sorted by difficulty are shown in Appendix 24 – Person-Item Map Sorted, Round 2.

The second round of selection was carried out as in the first round according to the outfit and infit mean square scores. Again, items with scores outside the 0.5–1.5 range were discarded. The exceptions were again items 60 and 61, where after the first selection and recalculation, only item 60 was out of the interval. Chi-squared values, degrees of freedom, and significance level were calculated; along with outfit and infit mean square and outfit and infit t-statistics.

In the second round, items 1, 4, 18, 26, 27, 30, 34, 37, and 55 were removed from the item bank. Thus, a total of 9 items were removed from the item bank after the second round of selection. For the third round of selection, 42 items remained in the item bank. All absolute fit values are shown in Table 2 – Absolute Fit: Round 2. Items that were eliminated in the second round of selection because their values did not fit within the 0.5–1.5 outfit and infit mean square interval are marked in bold and colour. For example, item 30 with a value of 2.401 was eliminated, as well as item 26, whose values for both observed statistics, 1.653 and 1.624, did not fit within the interval.

##	Chisq	df	p-value	Outfit MSQ	Infit MSQ	Outfit t	Infit t
## **Item.1**	550.900	352	0.000	**1.561**	1.154	0.80	0.86
## Item.2	303.285	352	0.971	0.859	1.205	-0.21	2.18
## Item.3	207.202	352	1.000	0.587	0.838	-1.05	-1.90
## **Item.4**	606.797	352	0.000	**1.719**	1.026	1.49	0.32
## Item.5	462.631	352	0.000	1.311	0.998	0.62	0.02
## Item.6	245.374	352	1.000	0.695	0.969	-1.30	-0.35
## Item.7	198.160	352	1.000	0.561	0.737	-2.00	-3.46
## Item.9	216.939	352	1.000	0.615	0.753	-1.27	-3.11
## Item.10	188.572	352	1.000	0.534	0.742	-2.86	-3.68
## Item.11	178.529	352	1.000	0.506	0.705	-2.84	-4.13
## Item.12	240.382	352	1.000	0.681	0.829	-1.65	-2.27
## Item.15	344.020	352	0.609	0.975	0.933	0.13	-0.69
## Item.16	186.895	352	1.000	0.529	0.868	-1.15	-1.51
## **Item.18**	683.577	352	0.000	**1.936**	0.994	1.07	0.01
## Item.19	335.462	352	0.728	0.950	1.015	-0.03	0.20
## Item.20	260.388	352	1.000	0.738	0.851	-1.40	-1.99
## Item.23	318.205	352	0.902	0.901	0.965	-0.30	-0.39
## Item.24	298.749	352	0.982	0.846	0.992	-0.20	-0.05
## **Item.26**	583.638	352	0.000	**1.653**	**1.624**	1.92	6.97
## **Item.27**	594.366	352	0.000	**1.684**	1.302	2.43	3.37
## **Item.30**	847.641	352	0.000	**2.401**	1.316	2.05	3.05
## Item.31	484.399	352	0.000	1.372	1.185	1.53	2.17
## **Item.34**	594.090	352	0.000	**1.683**	1.343	1.29	3.37
## Item.36	419.889	352	0.007	1.189	1.065	0.54	0.73
## **Item.37**	627.785	352	0.000	**1.778**	1.129	3.10	1.59
## Item.38	243.824	352	1.000	0.691	0.740	-1.83	-3.90
## Item.39	257.422	352	1.000	0.729	0.837	-1.36	-2.44
## Item.40	204.808	352	1.000	0.580	0.811	-1.71	-2.71
## Item.41	445.304	352	0.001	1.261	1.183	0.86	2.04
## Item.42	180.214	352	1.000	0.511	1.063	0.05	0.37

## Item.43	242.001	352	1.000	0.686	1.067	-0.67	0.76
## Item.44	289.683	352	0.993	0.821	1.021	-0.47	0.27
## Item.49	192.916	352	1.000	0.547	0.680	-2.18	-4.35
## Item.50	252.654	352	1.000	0.716	0.746	-0.95	-3.23
## Item.52	251.981	352	1.000	0.714	0.817	-0.93	-2.25
## Item.53	314.765	352	0.924	0.892	0.982	-0.33	-0.18
## Item.54	459.134	352	0.000	1.301	1.238	1.32	2.78
## Item.55	595.711	352	0.000	1.688	1.161	2.68	1.93
## Item.56	511.976	352	0.000	1.450	1.269	2.19	3.49
## Item.60	129.717	352	1.000	0.367	0.723	-1.14	-2.90
## Item.61	181.004	352	1.000	0.513	0.789	-0.35	-1.70
## Item.62	232.826	352	1.000	0.660	0.838	-2.04	-2.35
## Item.63	336.241	352	0.718	0.953	0.981	-0.18	-0.25
## Item.65	315.665	352	0.918	0.894	0.926	-0.51	-1.05
## Item.66	326.888	352	0.828	0.926	0.956	-0.31	-0.61
## Item.67	309.981	352	0.948	0.878	0.937	-0.49	-0.89
## Item.68	271.130	352	1.000	0.768	0.975	-0.89	-0.33
## Item.70	416.127	352	0.010	1.179	1.176	0.78	2.06
## Item.71	237.543	352	1.000	0.673	0.921	-1.12	-1.04
## Item.72	272.089	352	0.999	0.771	0.990	-0.64	-0.09
## Item.74	235.605	352	1.000	0.667	0.802	-0.21	-1.73

Table 2 Absolute Fit: Round 2 (chisq – chi-square; df – degree of freedom; MSQ – mean square)

5.5 Third Selection Round

In the third round, 42 items were analysed, in the same manner as in the first two rounds, based on data collected from 357 participants. Difficulty scores were calculated for each item and ranged from −4.34 logits for the easiest item (item 42) to 3.24 logits for the most difficult item (item 61). Standard errors of estimation were also calculated for each item. The item difficulty scores and standard errors of estimates for all 42 items are given in Appendix 25 – Item Difficulty, Standard Error, Round 3.

Applying conditional maximum likelihood, the item difficulty values ranged from 3.94 logits for item 42 to −5.07 logits for item 61. Again, the calculation is done as the "simplicity" of the items, so that positive and negative values are reversed compared to the marginal maximum likelihood approach (easiest items are positive). The standard error of the estimate and the lower and upper confidence intervals were also calculated.

All values are shown in Appendix 26 – Item Difficulty, Conditional Maximum Likelihood, Round 3.

The fit of the model was checked by goodness of fit using Pearson's chi-square. Its value was p = 1 and the data fit the model by value.

The descriptive statistics of the model were evaluated and 89.44% of the items were within the {−4, 4} logits interval, corresponding to almost 38 items out of 42.

Again, item and person fit were calculated. Plots of item characteristic curves (Appendix 27 – Plotted Item Characteristic Curves, Round 3) and item information curves (Appendix 28 – Plotted Item Information Curves, Round 3) were generated, as well as a test information function with standard error (Appendix 29 – Plotted Test Information Function, Round 3). The plot shows an "anomaly" of decreasing test information with increasing error. The reliability of the 42-item test, calculated using Cronbach's alpha, was 0.964, with a confidence interval of {0.958; 0.969}.

A Mokken analysis was also carried out for the third round. The values of unidimensionality calculated using the Mokken analysis were in the interval of H = {0,862–0,481} for individual items and H = 0.606, SE = 0.019, for the whole test. None of the items showed values indicating low stability of unidimensionality. The values for each item are shown in Appendix 30 – Unidimensionality, Round 3.

The monotonicity of the third selection round was not broken for any item. The values are shown in Appendix 31 – Monotonicity, Round 3.

For the third round of selection, five violations of invariant item ordering were recorded, as shown in Appendix 32 – Invariant Item Ordering, Round 3. The H-value for the whole test was H = 0.516. Despite these violations, the reliability was calculated as rho = 0.967.

Again, an item-person map was produced, showing the distribution of items and subjects on the scale (Appendix 33 – Person-Item Map, Round 3). It shows that the distribution of item difficulty still covers the full range of difficulty. The differences in difficulty between items have however increased slightly. This is also confirmed by Appendix 34 – Person-Item Map Sorted, Round 3, which shows the distribution of items and respondents sorted by difficulty from the easiest to the most difficult.

The third round of selection was carried out in the same way as the first and second rounds, according to the outfit and infit mean square values. Again, items that were not in the 0.5–1.5 interval were discarded. The only exceptions were items 60 and 61, where again only item 60 did not fit the interval. Chi-squared values, degrees of freedom, and significance level were calculated, as well as outfit and infit mean square and outfit and infit t-statistics.

In the third round of selection, items 5, 11, 31, 36, 54, and 56 were removed from the item bank. Thus, a total of 6 items were removed from the item bank after the third round of selection. For the fourth round, 36 items remained in the item bank. All absolute fit values are listed in Table 3 – Absolute Fit: Round 3. Items in bold and colour are those that were eliminated in the third round of selection because their values did not fit within the 0.5–1.5 outfit and infit mean square interval. For example, item 5 with a value of 2.109 and item 11 with a value of 0.478 were eliminated.

```
##            Chisq  df p-value Outfit MSQ Infit MSQ Outfit t Infit t
## Item.2  335.348 344   0.621      0.972     1.351     0.10    3.43
## Item.3  218.490 344   1.000      0.633     0.900    -0.75   -1.08
## Item.5  727.691 344   0.000      2.109     1.097     1.23    0.81
## Item.6  251.472 344   1.000      0.729     1.008    -1.00    0.12
## Item.7  192.648 344   1.000      0.558     0.738    -1.79   -3.34
## Item.9  296.870 344   0.969      0.860     0.794    -0.28   -2.46
## Item.10 180.091 344   1.000      0.522     0.737    -2.62   -3.66
## Item.11 164.897 344   1.000      0.478     0.700    -2.72   -4.10
## Item.12 245.219 344   1.000      0.711     0.867    -1.30   -1.68
## Item.15 439.559 344   0.000      1.274     0.922     0.61   -0.77
## Item.16 188.325 344   1.000      0.546     0.849    -0.92   -1.66
## Item.19 445.780 344   0.000      1.292     1.059     0.81    0.67
## Item.20 276.121 344   0.997      0.800     0.901    -0.90   -1.26
## Item.23 382.884 344   0.073      1.110     1.029     0.46    0.36
## Item.24 306.927 344   0.925      0.890     0.980    -0.05   -0.18
## Item.31 628.081 344   0.000      1.821     1.292     2.68    3.22
## Item.36 686.720 344   0.000      1.990     1.221     1.64    2.20
## Item.38 288.880 344   0.986      0.837     0.768    -0.75   -3.33
## Item.39 289.424 344   0.985      0.839     0.918    -0.59   -1.13
## Item.40 233.505 344   1.000      0.677     0.875    -0.95   -1.64
## Item.41 504.800 344   0.000      1.463     1.253     1.25    2.66
## Item.42 180.594 344   1.000      0.523     1.044     0.22    0.29
## Item.43 243.449 344   1.000      0.706     1.078    -0.50    0.84
## Item.44 289.219 344   0.986      0.838     1.037    -0.34    0.44
```

## Item.49	216.247	344	1.000	0.627	0.708	-1.51	-3.82
## Item.50	281.803	344	0.994	0.817	0.776	-0.47	-2.73
## Item.52	242.407	344	1.000	0.703	0.822	-0.85	-2.12
## Item.53	339.074	344	0.565	0.983	1.018	0.04	0.24
## Item.54	561.877	344	0.000	1.629	1.307	2.25	3.41
## Item.56	591.234	344	0.000	1.714	1.318	2.80	3.93
## Item.60	126.683	344	1.000	0.367	0.735	-0.71	-2.51
## Item.61	192.775	344	1.000	0.559	0.881	0.05	-0.78
## Item.62	287.795	344	0.988	0.834	0.874	-0.76	-1.75
## Item.63	362.448	344	0.237	1.051	1.038	0.29	0.54
## Item.65	377.428	344	0.104	1.094	0.939	0.48	-0.82
## Item.66	361.027	344	0.253	1.046	0.984	0.27	-0.19
## Item.67	317.649	344	0.843	0.921	0.974	-0.21	-0.33
## Item.68	289.999	344	0.984	0.841	1.010	-0.42	0.15
## Item.70	510.683	344	0.000	1.480	1.255	1.66	2.82
## Item.71	260.371	344	1.000	0.755	1.012	-0.58	0.17
## Item.72	301.927	344	0.950	0.875	1.071	-0.23	0.81
## Item.74	260.038	344	1.000	0.754	0.738	0.03	-2.28

Table 3 Absolute Fit: Round 3 (chisq – chi-square; df – degree of freedom; MSQ – mean square)

5.6 Fourth Selection Round

In the fourth round, 36 items were analysed, the same as in the first three rounds, based on data collected from 357 participants. Difficulty scores were calculated for each item, ranging from −4.36 logits for the easiest item (item 42) to 3.24 logits for the most difficult one (item 61). Standard errors of estimation were also calculated for each item. Item difficulty scores and standard errors of estimates for all 36 items are given in Appendix 35 – Item Difficulty, Standard Error, Round 4.

Following from conditional maximum likelihood, the item difficulty values ranged from 4.23 logits for item 42 to −5.19 logits for item 61. Again, the calculation is done as the “simplicity” of the items, so positive and negative values are reversed when compared to the marginal maximum likelihood approach (easiest items are positive). The standard error of the estimate and the lower and upper confidence intervals have also been calculated. All values are shown in Appendix 36 – Item Difficulty, Conditional Maximum Likelihood, Round 4.

The model fit was calculated by goodness-of-fit using Pearson's chi-square. Its p-value was p = 1, so the model fits the data.

The descriptive statistics of the model were evaluated and 89.44% of the items were within the {−4, 4} logits interval, corresponding to approximately 32 items out of 36.

The item and person fit was calculated. An item characteristic curve plot (Appendix 37 – Plotted Item Characteristic Curves, Round 4), showing the shape of the curves and the resulting probability of a correct response to an item at the latent trait level, and an item information curve plot (Appendix 38 – Plotted Item Information Curves, Round 4), showing the amount of information at the latent trait level, were generated. A test information function plot (Appendix 39 – Plotted Test Information Function, Round 4) was also generated, showing a continuing tendency towards the already-discussed "anomaly" with decreasing information as the standard error increases. To calculate reliability, Cronbach's alpha was 0.959 and the confidence interval was {0.953; 0.965}.

Reliability was checked also for the fourth selection round using Mokken analysis. To assess unidimensionality for the fourth round of selection, H = {0.87–0.474} values were found for each item, as shown in Appendix 40 – Unidimensionality, Round 4. Only one item can no longer be described as stable and unidimensional. The whole test yielded a value of H = 0.631 with a standard error of 0.02. This confirms that the scale is unidimensional.

The monotonicity assessment manifested no violations, as shown in Appendix 41 – Monotonicity, Round 4.

For the fourth round of selection, four violations of invariant item ordering were found, as illustrated in Appendix 42 – Invariant Item Ordering, Round 4, where the value of H is 0.553. Despite the violations of the assumption, reliability was calculated with a coefficient value of rho = 0.965.

A person-item map was also produced (Appendix 43 – Person-Item Map, Round 4). The map illustrates that although the differences in difficulty among the items have increased slightly, the distribution of item difficulty still covers the whole range of difficulty. This fact is even more evident in Appendix 44 – Person-Item Map Sorted, Round 4, where the items are sorted by difficulty.

The fourth round of selection was conducted in the same way as the first three rounds, according to the outfit and infit mean square values; and items that did not fit the 0.5–1.5 interval were again eliminated. The only exceptions are items 60 and 61, where only item 60 did not fit into the interval. Chi-squared values, degrees of freedom, significance level, outfit and infit mean square, and outfit and infit t-statistics were calculated.

In the fourth round of selection, items 2, 41, and 70 were removed from the item bank. In total, 3 items were removed from the item bank after the fourth round of selection. For the fifth round, a total of 33 items remained in the item bank. All absolute fit values are shown in Table 4 – Absolute Fit: Round 4. Items in bold and red are those that were eliminated in the fourth round of selection because their values did not fit in the 0.5–1.5 outfit and infit mean square interval. For example, item 2 was eliminated with a value of 1.536 and item 70 was eliminated with a value of 1.733.

```
##            Chisq  df p-value Outfit MSQ Infit MSQ Outfit t Infit t
## Item.2   412.540 341   0.005      1.206     1.536     0.54    4.77
## Item.3   229.378 341   1.000      0.671     0.957    -0.56   -0.42
## Item.6   290.949 341   0.977      0.851     1.090    -0.43    1.05
## Item.7   193.087 341   1.000      0.565     0.777    -1.61   -2.78
## Item.9   318.972 341   0.799      0.933     0.829    -0.04   -1.96
## Item.10 185.860 341   1.000      0.543     0.777    -2.24   -3.04
## Item.12 252.024 341   1.000      0.737     0.910    -1.06   -1.11
## Item.15 460.415 341   0.000      1.346     0.912     0.68   -0.82
## Item.16 176.330 341   1.000      0.516     0.826    -0.89   -1.84
## Item.19 487.403 341   0.000      1.425     1.072     1.01    0.79
## Item.20 272.413 341   0.997      0.797     0.897    -0.82   -1.31
## Item.23 456.288 341   0.000      1.334     1.037     1.06    0.45
## Item.24 299.494 341   0.949      0.876     0.951    -0.04   -0.47
## Item.38 375.740 341   0.095      1.099     0.787     0.48   -3.02
## Item.39 338.852 341   0.523      0.991     0.943     0.07   -0.74
## Item.40 238.775 341   1.000      0.698     0.894    -0.70   -1.31
## Item.41 522.598 341   0.000      1.528     1.282     1.30    2.88
## Item.42 183.271 341   1.000      0.536     1.080     0.39    0.46
## Item.43 235.262 341   1.000      0.688     1.071    -0.46    0.74
## Item.44 287.165 341   0.984      0.840     0.999    -0.29    0.02
## Item.49 228.633 341   1.000      0.669     0.710    -1.19   -3.77
## Item.50 297.337 341   0.958      0.869     0.790    -0.25   -2.50
## Item.52 247.772 341   1.000      0.724     0.850    -0.69   -1.72
## Item.53 481.557 341   0.000      1.408     1.082     1.23    0.95
## Item.60 126.498 341   1.000      0.370     0.730    -0.45   -2.53
## Item.61 193.087 341   1.000      0.565     0.844     0.25   -1.04
## Item.62 284.415 341   0.989      0.832     0.867    -0.67   -1.82
## Item.63 359.897 341   0.231      1.052     1.037     0.28    0.52
## Item.65 442.794 341   0.000      1.295     0.947     1.14   -0.70
## Item.66 423.200 341   0.002      1.237     1.000     0.90    0.03
## Item.67 333.160 341   0.609      0.974     0.985     0.02   -0.17
## Item.68 298.638 341   0.952      0.873     1.026    -0.23    0.35
## Item.70 592.550 341   0.000      1.733     1.305     2.18    3.31
## Item.71 269.924 341   0.998      0.789     1.058    -0.35    0.69
```

```
## Item.72 317.979 341   0.810       0.930      1.153    -0.04     1.63
## Item.74 260.675 341   1.000       0.762      0.675     0.12    -2.75
```

Table 4 Absolute Fit: Round 4 (chisq – chi-square; df – degree of freedom; MSQ – mean square)

5.7 Fifth Selection Round

In the fifth round of selection, 33 items were analysed, based on data collected from 357 participants. Difficulty scores were calculated for each item, ranging from −4.39 logits for the easiest item (item 42) to 3.24 logits for the most difficult one (item 61). Standard errors of estimation were calculated for each item. Item difficulty scores and standard errors of estimates for all 33 items are listed in Appendix 45 – Item Difficulty, Standard Error, Round 5.

Applying conditional maximum likelihood, the item difficulty values ranged from 4.64 logits for item 42 to −5.2 logits for item 61. Again, the calculation is conceived as the "simplicity" of the items, hence positive and negative values are reversed compared to the marginal maximum likelihood approach (easiest items are positive). The standard error of the estimate and the lower and upper confidence intervals were calculated. All values are shown in Appendix 46 – Item Difficulty, Conditional Maximum Likelihood, Round 5.

Pearson's chi-squared goodness-of-fit was employed to test the fit of the model. Its value was $p = 1$, so it can be concluded that the data fit the model.

The descriptive statistics of the model were evaluated, on which 89.23% of the items were within the {−4, 4} logits interval, corresponding to 29 items out of 33.

Furthermore, item and person fit were calculated. Plots of the item characteristic curves (Appendix 47 – Plotted Item Characteristic Curves, Round 5), item information curves (Appendix 48 – Plotted Item Information Curves, Round 5), and test information function with standard error (Appendix 49 – Plotted Test Information Function, Round 5) were produced, which continue to show the already-discussed "anomaly" of decreasing values of test information. Reliability calculated using Cronbach's alpha was 0.958, with a confidence interval of {0.951; 0.964}.

For the fifth round of selection, the unidimensionality of the test was found to be $H = 0.659$, $SE = 0.02$, when reliability was checked using Mokken analysis. The values for each item are listed in Appendix 50 – Unidimensionality, Round 5, which shows the values of H = {0,874–0,563}. All items can be described as very stable based on the calculated values.

In the fifth round of selection, the monotonicity of the items was not violated, which is confirmed by Appendix 51 – Monotonicity, Round 5.

The invariant item ordering was no longer violated in the fifth round, as evidenced by Appendix 52 – Invariant Item Ordering, Round 5. The H-value of the test was H = 0.57. When the assumptions were met, reliability was calculated with a value of rho = 0.964.

Again, a map of the distribution of items and participants on the scale was produced (Appendix 53 – Person-Item Map, Round 5). Although the differences in difficulty among the items increased slightly again, the map shows that the distribution of item difficulty still covers the full range of difficulty, which is even more evident when the items are sorted by difficulty, starting with the easiest (Appendix 54 – Person-Item Map Sorted, Round 5).

The fifth round of item bank selection was carried out in the same way as the first four rounds, according to the outfit and infit mean square values, and items that did not fit the 0.5–1.5 interval were eliminated, with the exception of items 60 and 61. Again, only item 60 did not fit the interval, while item 61 did. Chi-squared values, degrees of freedom, and significance level were calculated. Finally, outfit and infit mean square as well as outfit and infit t-statistics were calculated.

In the fifth round of selection, items 15, 16, 19, 38, 53, 65, and 66 were eliminated from the item bank. In this selection round, 7 items were removed and 26 items remained in the item bank. All absolute fit values are shown in Table 5 – Absolute Fit: Round 5. The bold and coloured items are those that were eliminated in the fifth round of selection because their values did not fit within the 0.5–1.5 outfit and infit mean square interval. For example, item 65 with a value of 1.795 or item 66 with a value of 1.687 were eliminated.

```
##            Chisq  df p-value Outfit MSQ Infit MSQ Outfit t Infit t
## Item.3   265.665 339   0.999      0.781     1.057    -0.24    0.59
## Item.6   352.945 339   0.290      1.038     1.156     0.22    1.75
## Item.7   196.867 339   1.000      0.579     0.793    -1.43   -2.53
## Item.9   388.838 339   0.032      1.144     0.852     0.46   -1.65
## Item.10  195.193 339   1.000      0.574     0.788    -1.86   -2.81
## Item.12  257.494 339   1.000      0.757     0.940    -0.88   -0.71
## Item.15  519.886 339   0.000      1.529     0.906     0.85   -0.81
## Item.16  168.249 339   1.000      0.495     0.824    -0.84   -1.78
## Item.19  575.820 339   0.000      1.694     1.110     1.39    1.14
## Item.20  303.715 339   0.916      0.893     0.917    -0.33   -1.03
## Item.23  469.136 339   0.000      1.380     1.071     1.12    0.82
## Item.24  317.672 339   0.791      0.934     0.970     0.10   -0.25
## Item.38  526.803 339   0.000      1.549     0.804     1.87   -2.68
```

```
## Item.39 355.831 339   0.254        1.047      0.978       0.25   -0.26
## Item.40 240.530 339   1.000        0.707      0.911      -0.52   -1.08
## Item.42 249.627 339   1.000        0.734      1.239       0.71    1.12
## Item.43 257.179 339   1.000        0.756      1.155      -0.25    1.47
## Item.44 335.771 339   0.539        0.988      1.038       0.12    0.43
## Item.49 241.497 339   1.000        0.710      0.733      -0.93   -3.38
## Item.50 317.440 339   0.794        0.934      0.799      -0.04   -2.35
## Item.52 246.106 339   1.000        0.724      0.846      -0.63   -1.75
## Item.53 516.096 339   0.000        1.518      1.101       1.41    1.13
## Item.60 117.993 339   1.000        0.347      0.702      -0.29   -2.86
## Item.61 203.700 339   1.000        0.599      0.832       0.42   -1.14
## Item.62 289.294 339   0.976        0.851      0.895      -0.49   -1.38
## Item.63 366.392 339   0.147        1.078      1.065       0.35    0.86
## Item.65 610.251 339   0.000        1.795      0.961       2.30   -0.50
## Item.66 573.573 339   0.000        1.687      1.015       1.90    0.21
## Item.67 343.939 339   0.415        1.012      0.990       0.16   -0.10
## Item.68 298.645 339   0.944        0.878      1.025      -0.14    0.33
## Item.71 287.718 339   0.980        0.846      1.103      -0.13    1.19
## Item.72 364.228 339   0.166        1.071      1.244       0.31    2.45
## Item.74 284.696 339   0.985        0.837      0.636       0.28   -2.88
```

Table 5 Absolute Fit: Round 5 (chisq – chi-square; df – degree of freedom; MSQ – mean square)

5.8 Sixth Selection Round

In the sixth round of selection, 26 items were analysed, as in the previous five rounds, based on data collected from 357 subjects. Difficulty scores were calculated for each item, ranging from −4.29 logits for the easiest item (item 42) to 3.17 logits for the most difficult one (item 61). Standard errors of estimation were calculated for each item. The item difficulty scores and standard errors of estimates for all 26 items are given in Appendix 55 – Item Difficulty, Standard Error, Round 6.

Using conditional maximum likelihood, the item difficulty values ranged from 4.73 logits for item 42 to −5.08 logits for item 61. The calculation is done as the "simplicity" of the items, so that positive and negative values are reversed compared to the marginal maximum likelihood approach (the easiest items are positive). The standard error of the estimate and the lower and upper confidence intervals have also been calculated. All values are shown in Appendix 56 – Item Difficulty, Conditional Maximum Likelihood, Round 6.

The appropriateness of the model was checked by goodness-of-fit using Pearson's chi-square test. Its value was $p = 1$, and the data fit the model.

The descriptive statistics of the model were evaluated, with 89.05% of the items falling within the {−4, 4} logits interval, corresponding to 23 out of 26 items.

Again, item and person fit were analysed. Plots of item characteristic curves (Appendix 57 – Plotted Item Characteristic Curves, Round 6), item information curves (Appendix 58 – Plotted Item Information Curves, Round 6), and test information functions with standard error (Appendix 59 – Plotted Test Information Function, Round 6) were generated, where the "anomaly" becomes increasingly visible as the information function decreases and the standard error increases. The reliability calculated using Cronbach's alpha was 0.947, with a confidence interval of {0.939; 0.955}.

Mokken analyses were also carried out for the sixth round to assess reliability. For this round, the unidimensionality values were H = {0,865–0,579}, and for the full test, the value was H = 0.674, with a standard error value of SE = 0.02. All items can be described as very stable and unidimensional. The scores for each item are shown in Appendix 60 – Unidimensionality, Round 6.

There was no violation of monotonicity for any item, as confirmed by Appendix 61 – Monotonicity, Round 6.

There was also no violation of invariant item ordering in the sixth round, as confirmed by Appendix 62 – Invariant Item Ordering, Round 6. The H-value of the whole test was H = 0.611. The reliability calculated by Mokken analysis, when all assumptions were met, was rho = 0.955.

Again, a map of the distribution of items and respondents on the scale was produced (Appendix 63 – Person-Item Map, Round 6). Although the differences in difficulty among items increased slightly, the map shows that the distribution of item difficulty still covers the full range of difficulty.

This is even more evident when looking at Appendix 64 – Person-Item Map Sorted, Round 6, where the items are sorted by difficulty, starting with the easiest. It is apparent that despite the removal of more than half of the items from the item bank, the remaining items still cover almost the entire range of item difficulty, especially in the interval between −2 and 3 logits, where most of the respondents lie according to the latent trait.

For the sixth selection round, the same parameters were set as for the previous five rounds. According to the outfit and infit mean square values, items that did not fit in the interval of 0.5–1.5 were to be discarded, with the exception of items 60 and 61, which were kept in the bank because they were the most difficult and were later used in the final assessment tool.

From the data evaluated during the sixth round of selection, it appeared that no further items needed to be removed from the item bank based on the outfit and infit mean square values. Therefore, the significance level and p-values of the items were assessed, whereby the items should not correlate with each other. Items with values below 0.05 were removed from the item bank. These were items 23 and 50.

Thus, in the sixth round of selection, 2 items were eliminated based on p-values, and 24 items remained in the item bank for the seventh round of selection.

As in the previous rounds, chi-squared values, degrees of freedom, and significance level were calculated. Outfit and infit mean square and outfit and infit t-statistics were also calculated. All absolute fit values are presented in Table 6 – Absolute Fit: Round 6. Bold and coloured are the two items that were eliminated in the sixth round based on their values, with p-values below 0.05, indicating a correlation with some of the other items. Item 23 was eliminated with a p-value of 0.000, and item 50 was eliminated with a p-value of 0.001.

```
##            Chisq  df p-value Outfit MSQ Infit MSQ Outfit t Infit t
## Item.3   282.890 339   0.988      0.832     1.071    -0.13    0.72
## Item.6   337.047 339   0.520      0.991     1.198     0.08    2.06
## Item.7   199.853 339   1.000      0.588     0.822    -1.39   -2.03
## Item.9   349.216 339   0.339      1.027     0.848     0.21   -1.63
## Item.10  196.064 339   1.000      0.577     0.818    -1.85   -2.29
## Item.12  243.630 339   1.000      0.717     0.954    -1.07   -0.51
## Item.20  294.462 339   0.961      0.866     0.918    -0.45   -0.96
## Item.23  468.315 339   0.000      1.377     1.121     1.11    1.28
## Item.24  352.361 339   0.297      1.036     1.013     0.27    0.16
## Item.39  345.434 339   0.393      1.016     0.992     0.16   -0.08
## Item.40  243.182 339   1.000      0.715     0.904    -0.49   -1.21
## Item.42  215.750 339   1.000      0.635     1.059     0.66    0.36
## Item.43  272.076 339   0.997      0.800     1.167    -0.15    1.57
## Item.44  378.087 339   0.070      1.112     1.061     0.39    0.65
## Item.49  211.462 339   1.000      0.622     0.718    -1.31   -3.40
## Item.50  421.502 339   0.001      1.240     0.806     0.70   -2.16
## Item.52  284.268 339   0.986      0.836     0.939    -0.30   -0.62
## Item.60  111.180 339   1.000      0.327     0.662    -0.32   -3.32
## Item.61  160.970 339   1.000      0.473     0.827     0.33   -1.19
## Item.62  264.778 339   0.999      0.779     0.872    -0.78   -1.69
## Item.63  329.934 339   0.628      0.970     1.003     0.00    0.07
## Item.67  320.170 339   0.762      0.942     0.963    -0.03   -0.46
## Item.68  266.535 339   0.999      0.784     0.959    -0.37   -0.50
## Item.71  287.446 339   0.981      0.845     1.079    -0.12    0.96
## Item.72  359.091 339   0.217      1.056     1.258     0.27    2.49
## Item.74  275.500 339   0.995      0.810     0.707     0.27   -2.25
```

Table 6 Absolute Fit: Round 6 (chisq – chi-square; df – degree of freedom; MSQ – mean square)

5.9 Seventh Selection Round

In the seventh round of selection, 24 items were analysed, as in the previous six rounds, based on data collected from 357 participants. Difficulty scores were calculated for each item, ranging from −4.24 logits for the easiest item (item 42), to 3.16 logits for the most difficult item (item 61). Standard errors of estimate were also calculated for each item. The item difficulty scores and standard errors of estimate for all 24 items are given in Appendix 65 – Item Difficulty, Standard Error, Round 7.

Using conditional maximum likelihood, the item difficulty values ranged from 4.76 logits for item 42 to −5.05 logits for item 61. Again, the calculation is performed as the "simplicity" of the items, so positive and negative values are reversed compared to the marginal maximum likelihood approach (the simplest items are positive). The standard error of the estimate and the lower and upper confidence intervals have also been calculated. All values are shown in Appendix 66 – Item Difficulty, Conditional Maximum Likelihood, Round 7.

Pearson's chi-squared goodness-of-fit was used to test the fit of the model. The data fit the model; the value was $p = 1$.

The descriptive statistics of the model were evaluated, with 88.86% of the items falling within the {−4, 4} logits interval, corresponding to 21 out of 24 items.

Again, item and person fit were calculated. Plots of item characteristic curves (Appendix 67 – Plotted Item Characteristic Curves, Round 7), item information curves (Appendix 68 – Plotted Item Information Curves, Round 7), and test information function with standard error (Appendix 69 – Plotted Test Information Function, Round 7) were generated, showing an "anomaly" of decreasing test information as standard error increases. The reliability calculated using Cronbach's alpha was 0.942, with a confidence interval of {0.932; 0.950}.

Mokken analysis was used again in the seventh selection round to check reliability. In testing the assumptions, the unidimensionality values were in the range of H = {0,59–0,866}, with H = 0.682 for the full test. The standard error for the whole test is 0.02. The values for the individual items are given in Appendix 70 – Unidimensionality, Round 7.

Again, there was no violation of monotonicity for any item, as confirmed by Appendix 71 – Monotonicity, Round 7.

There was also no violation of invariant item ordering, as confirmed by Appendix 72 – Invariant Item Ordering, Round 7. Thus, all assumptions for the reliability test were met, and the value of the full test was H = 0.630, with reliability rho = 0.951.

A map of the distribution of items and participants on the scale was also produced for the seventh round of selection (Appendix 73 – Person-Item Map, Round 7). Although again the differences in difficulty among items increased slightly, the map shows that the distribution of item difficulty still covers the full range of difficulty.

Appendix 74 – Person-Item Map Sorted, Round 7 shows the distribution of items and participants sorted by difficulty from easiest to hardest. Here it can be seen even more clearly that although more than two thirds of the items are removed from the item bank, the remaining items still cover the full range of item difficulty, particularly in the interval of −2 to 3 logits, where most of the participants lie according to the latent trait.

For the seventh selection round, the same parameters were set as for all six previous rounds. According to the outfit and infit mean square values, items that did not fit in the interval of 0.5–1.5 were to be discarded, except for items 60 and 61, where the outfit mean square value of item 60 did not fit in the interval. However, both items were retained in the item bank due to their highest difficulty and subsequent use in the final assessment tool. P-values were also checked and were not allowed to be less than 0.05. According to the item analysis, all 24 items already fit the Rasch model and can be selected from the item bank for the assessment tool.

As in the previous rounds, chi-squared values, degrees of freedom, significance level, outfit and infit mean square, and outfit and infit t-values were calculated. All absolute fit values are presented in Table 7 – Absolute Fit: Round 7.

```
##            Chisq  df p-value Outfit MSQ Infit MSQ Outfit t Infit t
## Item.3   275.407 339   0.995      0.810     1.044    -0.15    0.47
## Item.6   316.305 339   0.807      0.930     1.185    -0.11    1.93
## Item.7   192.695 339   1.000      0.567     0.804    -1.43   -2.26
## Item.9   347.942 339   0.357      1.023     0.828     0.20   -1.88
## Item.10  194.172 339   1.000      0.571     0.824    -1.86   -2.20
## Item.12  244.051 339   1.000      0.718     0.943    -1.03   -0.63
## Item.20  297.746 339   0.948      0.876     0.931    -0.40   -0.80
## Item.24  360.532 339   0.202      1.060     1.033     0.31    0.35
## Item.39  345.570 339   0.391      1.016     1.000     0.16    0.02
## Item.40  261.879 339   0.999      0.770     0.938    -0.36   -0.75
## Item.42  174.298 339   1.000      0.513     1.019     0.60    0.16
## Item.43  260.586 339   0.999      0.766     1.125    -0.20    1.22
## Item.44  373.857 339   0.093      1.100     1.058     0.36    0.62
## Item.49  212.112 339   1.000      0.624     0.731    -1.25   -3.23
```

```
## Item.52 281.034 339   0.990       0.827      0.945     -0.30   -0.56
## Item.60 108.955 339   1.000       0.320      0.637     -0.33   -3.56
## Item.61 176.195 339   1.000       0.518      0.829      0.36   -1.18
## Item.62 267.616 339   0.998       0.787      0.872     -0.76   -1.67
## Item.63 331.972 339   0.597       0.976      1.009      0.02    0.14
## Item.67 302.105 339   0.926       0.889      0.967     -0.18   -0.40
## Item.68 267.460 339   0.998       0.787      0.966     -0.37   -0.40
## Item.71 287.041 339   0.981       0.844      1.094     -0.13    1.11
## Item.72 363.003 339   0.177       1.068      1.236      0.30    2.32
## Item.74 300.322 339   0.936       0.883      0.728      0.34   -2.10
```

Table 7 Absolute Fit: Round 7 (chisq – chi-square; df – degree of freedom; MSQ – mean square)

5.10 Summary of Item Calibration

Once the item bank had been created and the necessary data had been collected from 357 respondents, the individual items were analysed and during each round of selection, unsuitable items were progressively removed from the item bank based on the outfit and infit mean square scores. In the first round of selection, 23 items were eliminated from the item bank; in the second round, 9 items were eliminated; in the third round, 6 items were eliminated; in the fourth round, 3 items were eliminated; in the fifth round, 7 items were eliminated; and in the sixth round, 2 items were eliminated. In the seventh round of selection, all items appeared to fit the Rasch model, and no further items needed to be eliminated from the item bank.

Although during the selection process, items that did not fit the Rasch model were discarded, the scores of the two most difficult items in the item bank were taken into account, and the items were retained in the bank. This was a deliberate decision despite a slight violation of the rules for removing items from the item bank when they did not fit within the required interval.

Following a calibration and seven rounds of selection, 24 items remained in the item bank. These items fit the Rasch model, and it is now possible to proceed with the selection of items for the assessment tool.

5.11 Choosing Assessment Tool Items

Based on the analysed data from the seventh round of selection, all 24 items in the item bank fit the Rasch model according to the outfit and infit mean square statistics as well as the p-values, so no further items needed to be removed. The selection of items for the assessment tool was then carried out based on their difficulty.

After seven rounds of selection, the items in the item bank were ranked by difficulty. As indicated above, the difficulty of the items ranged from −4.24 logits (marginal maximum likelihood) and 4.76 logits (conditional maximum likelihood) to 3.16 logits and −5.05 logits (marginal maximum likelihood). In selecting items for the assessment tool, particular care was taken to ensure that items of similar difficulty were not unnecessarily left in the tool. Our aim was to select items for the assessment tool that spanned the full range of difficulty according to a normal Gaussian distribution, taking into account that it is appropriate to have items that are slightly more difficult. This is particularly important from a practical point of view, where the differences may be significant at the beginning of systematic training (around year 6), but the selection of players on the basis of the skills they have acquired is crucial at the end of school (around year 15) and beyond. Players should already have mastered all skills, so more items of higher difficulty are needed to differentiate players with more skills or higher latent trait scores. It would be therefore counterproductive to keep the items in the tool very easy. With similar item difficulty, the convenience of item preparation for coaches in practice was also considered, and items that were easier to prepare and score were preferred.

Eighteen items were eventually chosen for the assessment tool. These were items 3, 7, 10, 12, 20, 24, 39, 40, 49, 52, 60, 61, 62, 63, 67, 68, 71, and 72.

As in the previous seven rounds, all 18 selected items were analysed based on data collected from 357 participants. Difficulty scores were calculated for each item, ranging from −2.08 logits for the easiest item (item 24) to 3.10 logits for the most difficult item (item 61). Standard errors of estimation were calculated for each item. The item difficulty scores and standard errors of estimates for all 18 items are given in Appendix 75 – Item Difficulty, Standard Error, Selection.

Using conditional maximum likelihood, the item difficulty values fell within a range from 2.92 logits for item 24 to −4.32 logits for item 61. This is calculated as the "ease" of the items, with positive and negative values reversed compared to the marginal maximum likelihood approach, so that the easiest items are positive. The standard error of the estimate and the lower and upper confidence intervals have also been calculated. All values are shown in Appendix 76 – Item Difficulty, Conditional Maximum Likelihood, Selection.

Pearson's chi-squared goodness-of-fit was used to test the fit of the model. Its value was $p = 1$, and the data fit the model.

The descriptive statistics of the model were evaluated, with 92.08% of the items falling within the {−4, 4} logits interval, which corresponded to almost 17 items out of 18.

Item and person fit were calculated. Plots of item characteristic curves (Appendix 77 – Plotted Item Characteristic Curves, Selection), item information curves (Appendix 78 – Plotted Item Information Curves, Selection), and test information function (Appendix 79 – Plotted Test Information Function, Selection) were generated, with a steady decrease in information value and an increase in standard error, all at high test reliability values. The reliability calculated by Cronbach's alpha was 0.930, with a confidence interval of {0.920; 0.941}.

Using Mokken analysis, the unidimensionality values in the round of choosing items for the assessment tool were in a range of H = {0.651–0.853}, as shown in Appendix 80 – Unidimensionality, Selection. For the full test, the value was H = 0.689, with a standard error of SE = 0.021. We can then conclude that the items are stable, and the test assesses a single dimension or latent trait.

There was no violation of monotonicity, which is confirmed in Appendix 81 – Monotonicity, Selection.

There was no violation of invariant item ordering either, where the value of the H-coefficient for the whole test was H = 0.582. The reliability was rho = 0.941. The non-violation of invariant item ordering is confirmed in Appendix 82 – Invariant Item Ordering, Selection.

A map of the distribution of items and participants on the scale was produced (Appendix 83 – Person-Item Map, Selection), showing that the differences in difficulty among items increased slightly.

Appendix 84 – Person-Item Map Sorted, Selection depicts the distribution of items and participants sorted by difficulty from the easiest to the most difficult. Although more than three quarters of the items have been removed from the item bank, the remaining items still cover almost the entire range of item difficulty. This is particularly the case in the interval between −2 and 3 logits, where most of the participants lie according to the latent trait.

All 18 items were retested using the same parameters as in the previous rounds. The outfit and infit mean square scores were checked, for which an interval of 0.5–1.5 was set; except for items 60 and 61, where item 60 did not fit into the interval with respect to the outfit mean square scores. However, the item was retained in the instrument. In addition, p-values were tested with the condition of values greater than 0.05, with lower values indicating a correlation between items. Subsequently, the easiest item (item 24), which showed a significant correlation, was dropped from the instrument.

The chi-square values, degrees of freedom, significance level, outfit and infit mean square, and outfit and infit t-values are presented in Table 8 – Absolute Fit: Selection. Item 24, which was eliminated due to its p-values below 0.05 and a correlation with other selected items, is shown in bold and coloured.

		Chisq	df	p-value	Outfit MSQ	Infit MSQ	Outfit t	Infit t
##	Item.3	307.189	318	0.658	0.963	1.055	0.16	0.55
##	Item.7	180.092	318	1.000	0.565	0.825	-1.38	-1.90
##	Item.10	196.937	318	1.000	0.617	0.855	-1.80	-1.79
##	Item.12	259.172	318	0.993	0.812	0.981	-0.66	-0.18
##	Item.20	307.623	318	0.652	0.964	0.943	-0.07	-0.65
##	**Item.24**	401.404	318	**0.001**	1.258	1.180	0.57	1.62
##	Item.39	353.909	318	0.081	1.109	1.011	0.54	0.17
##	Item.40	254.265	318	0.996	0.797	0.940	-0.62	-0.72
##	Item.49	218.927	318	1.000	0.686	0.767	-0.96	-2.64
##	Item.52	285.225	318	0.907	0.894	0.976	-0.09	-0.21
##	Item.60	103.722	318	1.000	0.325	0.629	-0.93	-3.67
##	Item.61	199.998	318	1.000	0.627	0.817	0.06	-1.28
##	Item.62	260.479	318	0.992	0.817	0.869	-0.88	-1.74
##	Item.63	319.656	318	0.463	1.002	0.983	0.08	-0.19
##	Item.67	293.878	318	0.830	0.921	0.934	-0.25	-0.85
##	Item.68	255.688	318	0.996	0.802	0.943	-0.67	-0.71
##	Item.71	261.624	318	0.991	0.820	1.073	-0.46	0.88
##	Item.72	309.653	318	0.621	0.971	1.223	0.10	2.08

Table 8 – Absolute Fit: Selection (chisq – chi-square; df – degree of freedom; MSQ – mean square)

As one item was removed from the sample, the data had to be reanalysed and scored. This left 17 items in the assessment tool.

5.12 Assessment Tool

After seven rounds of selection, item selection, and analysis, 17 items were finally selected for the assessment tool. These were items 3, 7, 10, 12, 20, 39, 40, 49, 52, 60, 61, 62, 63, 67, 68, 71, and 72.

All 17 items included in the assessment tool were analysed, as in the previous rounds, based on data collected from 357 participants. Difficulty scores were calculated for each item, ranging from −1.91 logits for the easiest item (item 3) to 3.10 logits for the most difficult item (item 61). Standard errors of estimate were calculated for each item. The item difficulty scores and standard errors of estimates for all 17 items are shown in Table 9 – Item Difficulty, Standard Error, Assessment Tool. In the table, the difficulty scores are highlighted in bold and colour. Item 61 is the most difficult with a value of

3.0984 logits, while at the other end of the continuum, item 3 is the easiest with a value of −1.9081 logits.

```
##                    value  std.err
## Dffclt.Item.3    -1.9081   0.1624
## Dffclt.Item.7    -1.0664   0.1473
## Dffclt.Item.10   -0.4602   0.1418
## Dffclt.Item.12   -0.6860   0.1434
## Dffclt.Item.20   -0.5291   0.1422
## Dffclt.Item.39    0.4818   0.1407
## Dffclt.Item.40    1.0349   0.1447
## Dffclt.Item.49   -0.9921   0.1464
## Dffclt.Item.52   -1.4147   0.1523
## Dffclt.Item.60    2.4448   0.1768
## Dffclt.Item.61    3.0984   0.2078
## Dffclt.Item.62   -0.0202   0.1402
## Dffclt.Item.63    0.2469   0.1401
## Dffclt.Item.67    0.6510   0.1415
## Dffclt.Item.68    0.9108   0.1435
## Dffclt.Item.71    1.1985   0.1466
## Dffclt.Item.72   -1.5371   0.1545
```

Table 9 – Item Difficulty, Standard Error, Assessment Tool

Using conditional maximum likelihood, item difficulty values ranged from 2.90 logits for item 3 to −4.16 logits for item 61. This value is calculated as the "ease" of the items, with positive and negative values reversed in comparison the marginal maximum likelihood approach, so that the easiest items are positive here. The standard error of the estimate and the lower and upper confidence intervals were also calculated. The values for all items are presented in Table 10 – Item Difficulty, Conditional Maximum Likelihood, Assessment Tool. In the table, the difficulty values are highlighted in colour, which shows the same order of items on the scale as in the marginal maximum likelihood approach, but the values are reversed, and the easiest item 3 has a value of 2.901 logits, while the most difficult item 61 has a value of −4.161 logits.

```
## Item Easiness Parameters (beta) with 0.95 confidence interval (CI):
        ##                Estimate Std. Error Lower CI Upper CI
        ## beta Item.3       2.901      0.192    2.525    3.277
        ## beta Item.7       1.621      0.168    1.291    1.951
```

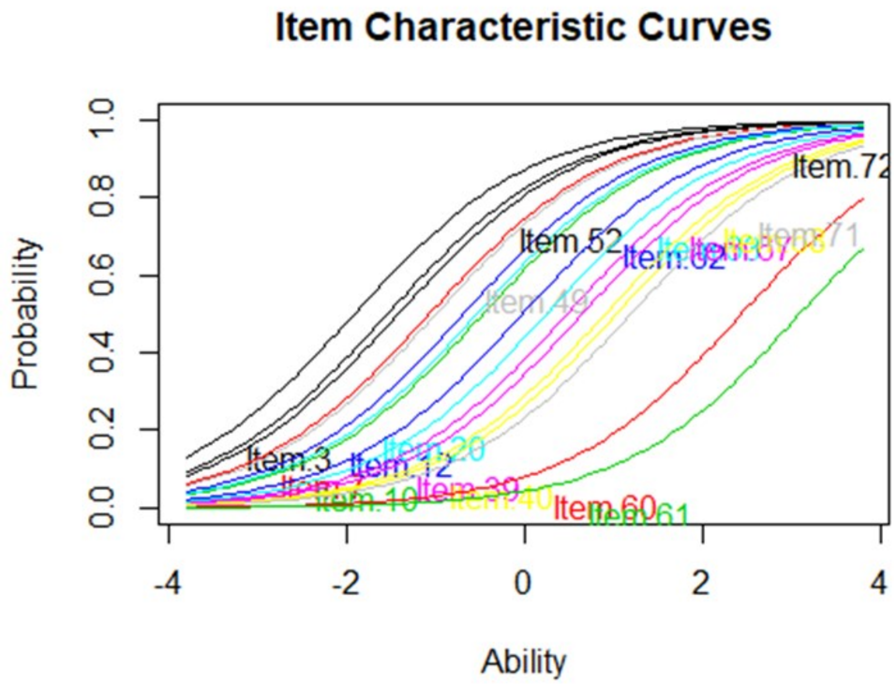
```
## beta Item.10     0.713      0.155     0.409     1.018
## beta Item.12     1.045      0.160     0.732     1.357
## beta Item.20     0.813      0.157     0.506     1.120
## beta Item.39    -0.594      0.150    -0.888    -0.301
## beta Item.40    -1.341      0.155    -1.646    -1.036
## beta Item.49     1.507      0.166     1.181     1.833
## beta Item.52     2.159      0.177     1.811     2.506
## beta Item.60    -3.265      0.205    -3.667    -2.864
## beta Item.61    -4.161      0.254    -4.659    -3.664
## beta Item.62     0.092      0.150    -0.203     0.386
## beta Item.63    -0.276      0.149    -0.568     0.017
## beta Item.67    -0.823      0.151    -1.119    -0.528
## beta Item.68    -1.173      0.154    -1.474    -0.872
## beta Item.71    -1.562      0.158    -1.873    -1.252
## beta Item.72     2.346      0.181     1.992     2.700
```

Table 10 – Item Difficulty, Conditional Maximum Likelihood, Assessment Tool

Goodness-of-fit and Pearson's chi-square were used to check the fit of the model. Its value was p = 1. The data fit the model.

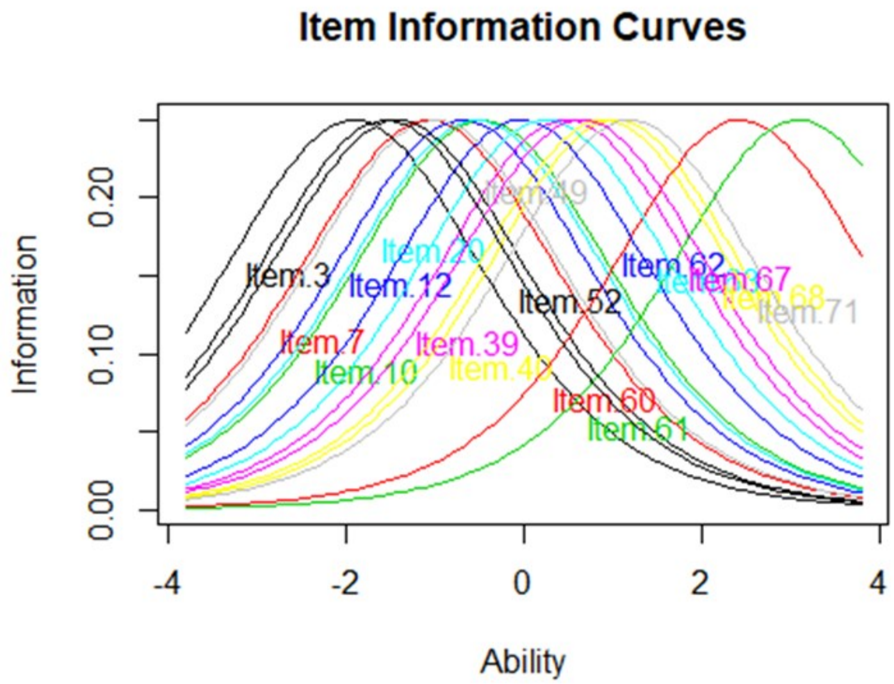
The descriptive statistics of the model were evaluated, and 92.4% of the items fell within the $\{-4, 4\}$ logits interval, corresponding to almost 16 out of 17 items.

Again, the item and person fit was calculated. A plot of the item characteristic curves (Plot 1 – Item Characteristic Curves, Assessment Tool) was generated, showing the pattern of dependence of the probability of correct response on the participant's latent trait. The plot illustrates that the further to the left an item is, the easier it is. The difference between items 3 and 61, which are the easiest and the most difficult, respectively, is apparent at first glance.



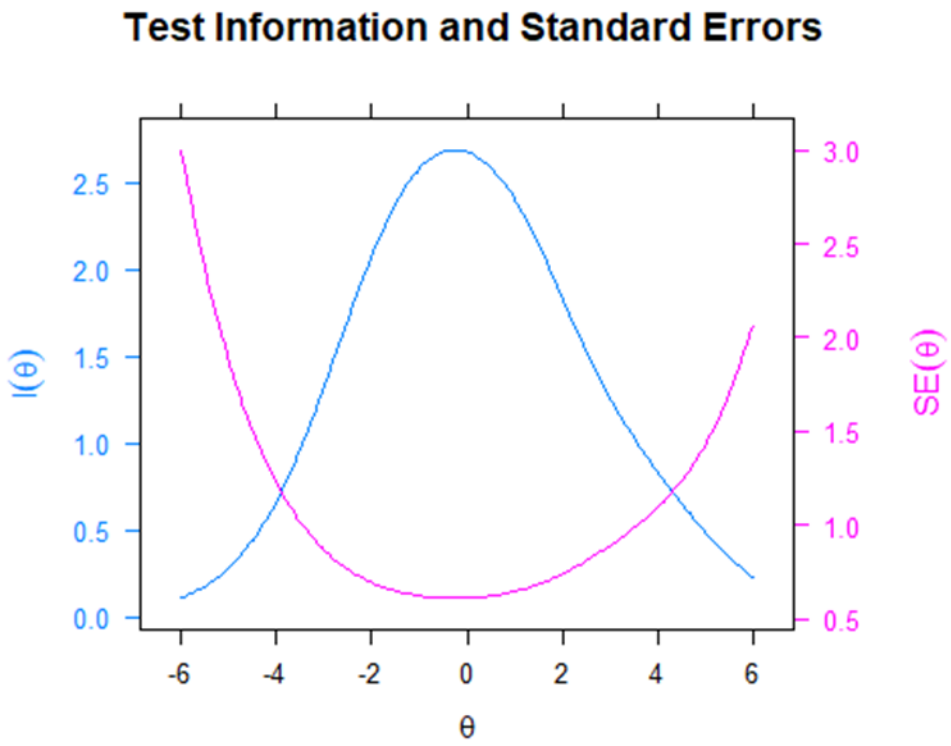
Plot 1 – Item Characteristic Curves, Assessment Tool

An item information curve (Plot 2 – Item Information Curve, Assessment Tool) was also generated, showing the information contribution of an item as a function of the participant's latent trait. The plot again shows the curves of the easier items on the left and the harder items on the right. The individual curves show the amount of information at a given level of the participant's latent trait. For example, item 3 provides the most information for participants with a latent trait level of about −2 logits. Conversely, for participants with a latent trait level of 3 logits or more, the amount of information obtained is minimal.



Plot 2 – Item Information Curve, Assessment Tool

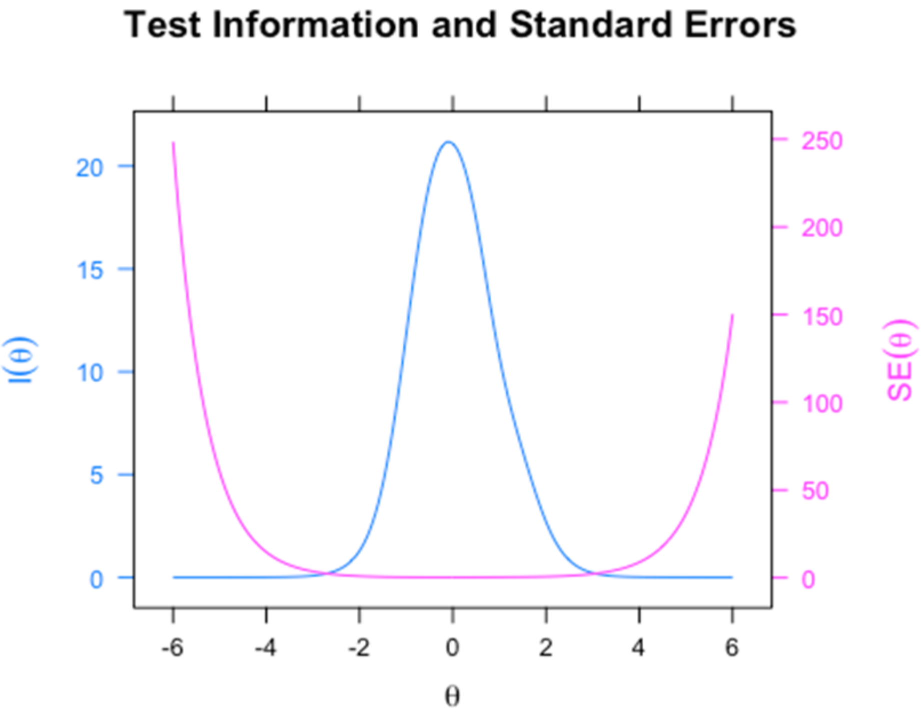
Plot 3 – Test Information Function, Assessment Tool shows the dependence of the test information function on the standard error. The plot illustrates that for participants with a latent trait moving away from zero, for the most difficult and easiest items, respectively, the standard error increases and the test information obtained decreases.



Plot 3 – Test Information Function, Assessment Tool

The reliability of the test, calculated using Cronbach's alpha, was 0.929 with a confidence interval of {0.918; 0.939}. Validity was assessed by expert judgement, as in all previous rounds. After each selection, there was a decrease in test information and an increase in the standard error, although the reliability (Cronbach's alpha) reached values close to one. This anomaly was caused by setting the value of the discriminant parameter to 1. However, a value of 1 is consistent with the Rasch model.

When calculating the test information and the standard error, we relaxed this constraint of the discriminant parameter for the same value but different from one (typical for a one-parameter model). The test information increased significantly more, while the standard error decreased. This is illustrated in Plot 4 – Test Information Function, Assessment Tool, 1PL. The plot shows that for difficulty levels −2 to 2, the test information is relatively high with minimal standard error. The reliability values now correspond to the test information and standard error values.



Plot 4 - Test Information Function, Assessment Tool, 1PL

Mokken analysis was carried out to confirm the reliability values and the above explanation of the anomaly caused by the constraint of the discriminant parameter. For the assessment tool items, the unidimensionality of the test was calculated as H = 0.691 with a standard error of SE = 0.021. The unidimensionality values in colour and bold for each item are shown in Table 11 – Unidimensionality, Assessment Tool. They took values in a range of H = {0.648–0.851}. The standard error values for each item are shown in parentheses. Since the values are above 0.5, it can be safely concluded that the items of our diagnostic tool are stable and the test is unidimensional.

```
##            Item H    se
## Item.3     0.734 (0.043)
## Item.7     0.730 (0.030)
## Item.10    0.704 (0.028)
## Item.12    0.666 (0.033)
## Item.20    0.662 (0.033)
## Item.39    0.648 (0.031)
## Item.40    0.686 (0.029)
## Item.49    0.736 (0.029)
## Item.52    0.703 (0.036)
## Item.60    0.851 (0.026)
## Item.61    0.830 (0.043)
```

##	Item.62	0.691	(0.028)
##	Item.63	0.655	(0.031)
##	Item.67	0.659	(0.032)
##	Item.68	0.665	(0.032)
##	Item.71	0.659	(0.034)
##	Item.72	0.673	(0.038)

Table 11 – Unidimensionality, Assessment Tool

It was verified that there was no monotonicity violation, which is confirmed by Table 12 – Monotonicity, Assessment Tool. The coloured zero values in column #zsig indicate that there was no significant monotonicity violation, just as the coloured values in column #vi indicate that there was no monotonicity violation.

##		ItemH	#ac	#vi	#vi/#ac	maxvi	sum	sum/#ac	zmax	#zsig	crit
##	Item.3	0.73	6	0	0	0	0	0	0	0	0
##	Item.7	0.73	6	0	0	0	0	0	0	0	0
##	Item.10	0.70	6	0	0	0	0	0	0	0	0
##	Item.12	0.67	6	0	0	0	0	0	0	0	0
##	Item.20	0.66	6	0	0	0	0	0	0	0	0
##	Item.39	0.65	6	0	0	0	0	0	0	0	0
##	Item.40	0.69	3	0	0	0	0	0	0	0	0
##	Item.49	0.74	6	0	0	0	0	0	0	0	0
##	Item.52	0.70	6	0	0	0	0	0	0	0	0
##	Item.60	0.85	1	0	0	0	0	0	0	0	0
##	Item.61	0.83	3	0	0	0	0	0	0	0	0
##	Item.62	0.69	3	0	0	0	0	0	0	0	0
##	Item.63	0.65	6	0	0	0	0	0	0	0	0
##	Item.67	0.66	6	0	0	0	0	0	0	0	0
##	Item.68	0.67	3	0	0	0	0	0	0	0	0
##	Item.71	0.66	3	0	0	0	0	0	0	0	0
##	Item.72	0.67	6	0	0	0	0	0	0	0	0

Table 12 – Monotonicity, Assessment Tool

The reliability assessment showed that there were no violations of invariant item ordering, which is confirmed by Table 13 – Invariant Item Ordering, Assessment Tool. The zero values coloured in the #zsig column indicate that there was no significant violation of invariant item ordering, just as the coloured values in the #vi column indicate that there was no violation of invariant item ordering. The test value was H = 0.566, and the reliability calculated using Mokken analysis was rho = 0.94.

##		ItemH	#ac	#vi	#vi/#ac	maxvi	sum	sum/#ac	zmax	#zsig	crit
##	Item.3	0.73	48	0	0	0	0	0	0	0	0
##	Item.72	0.67	48	0	0	0	0	0	0	0	0
##	Item.52	0.70	48	0	0	0	0	0	0	0	0

## Item.7	0.73	48	0	0	0	0	0	0	0	0
## Item.49	0.74	48	0	0	0	0	0	0	0	0
## Item.12	0.67	48	0	0	0	0	0	0	0	0
## Item.20	0.66	48	0	0	0	0	0	0	0	0
## Item.10	0.70	48	0	0	0	0	0	0	0	0
## Item.62	0.69	48	0	0	0	0	0	0	0	0
## Item.63	0.66	48	0	0	0	0	0	0	0	0
## Item.39	0.65	48	0	0	0	0	0	0	0	0
## Item.67	0.66	48	0	0	0	0	0	0	0	0
## Item.68	0.66	48	0	0	0	0	0	0	0	0
## Item.40	0.69	48	0	0	0	0	0	0	0	0
## Item.71	0.66	48	0	0	0	0	0	0	0	0
## Item.60	0.85	48	0	0	0	0	0	0	0	0
## Item.61	0.83	48	0	0	0	0	0	0	0	0

Table 13 – Invariant Item Ordering, Assessment Tool

A person-item map was created for the assessment tool (Figure 3 – Person-Item Map, Assessment Tool). The figure shows the difficulty of the item at the bottom and the distribution of the latent trait in the participant set at the top.

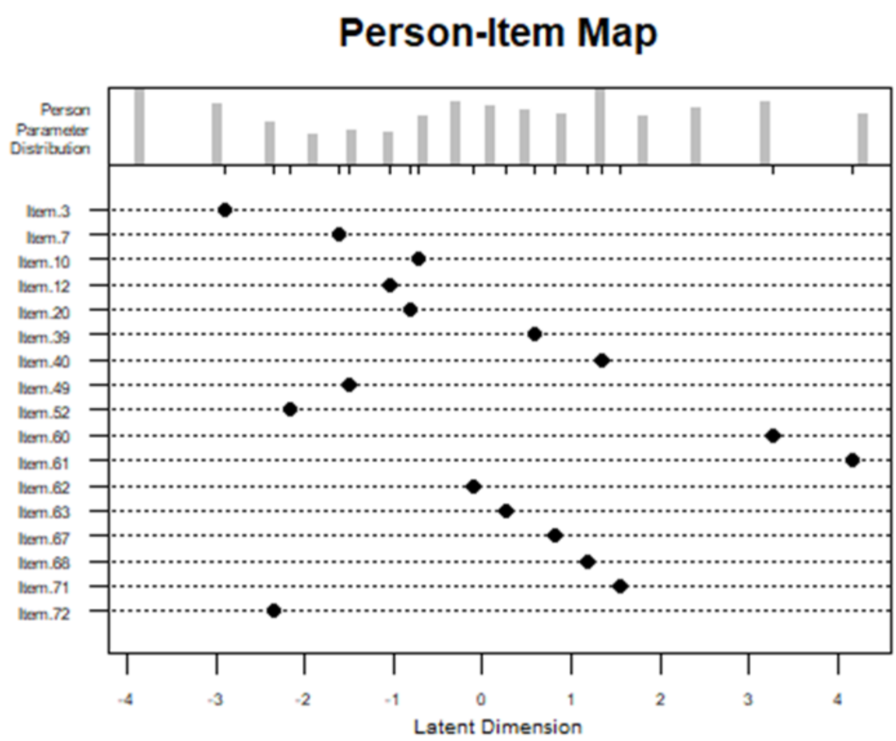


Figure 3 – Person-Item Map, Assessment Tool

Even after removing more than three-quarters of the items from the item bank and selecting items, the items remaining in the assessment tool covered the full range of difficulty. This is particularly the case in the {−3, 2} logits interval, where most of the respondents lie according to the latent trait. The lower part shows the difficulty of the items from top to bottom, with the easiest item 3 on the left and the most difficult item 61 on the right. Figure 4 – Person-Item Map Sorted, Assessment Tool shows the distribution of items and participants sorted by difficulty from the easiest to the most difficult.

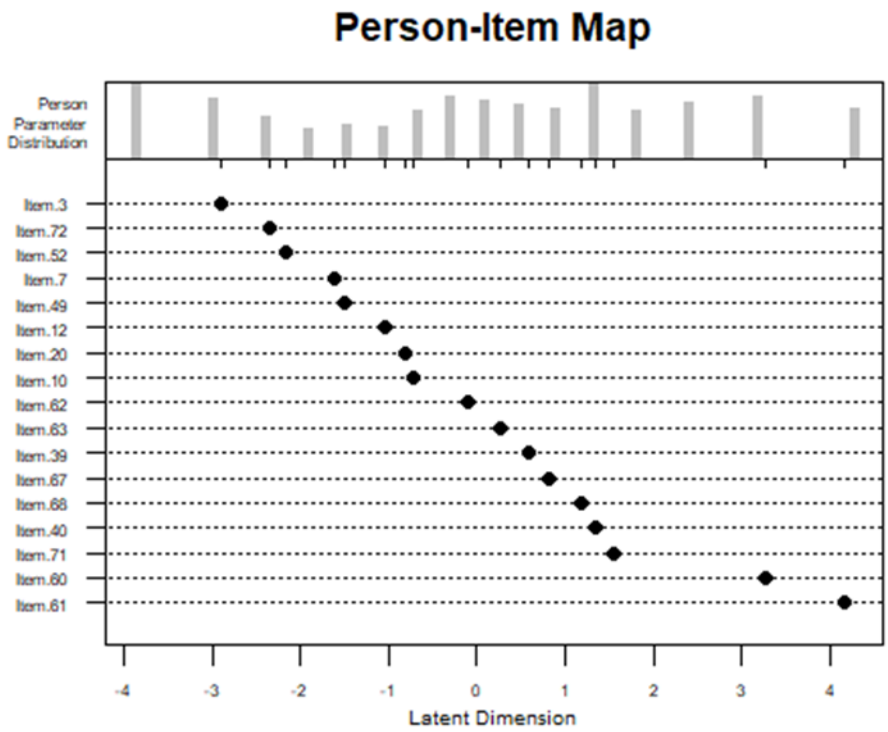


Figure 4 – Person-Item Map Sorted, Assessment Tool

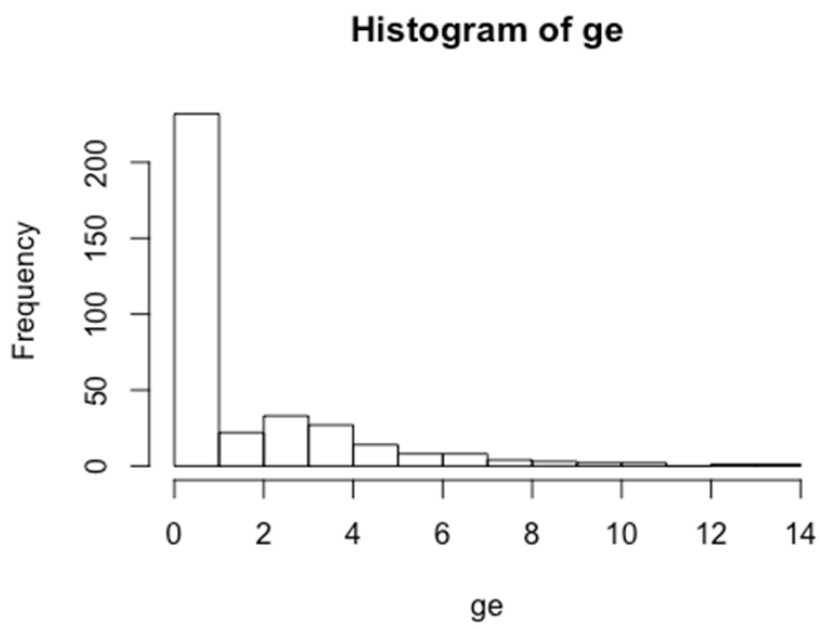
All 17 items were checked again using the same parameters as in the previous rounds. The outfit and infit mean square scores were checked, for which a range of 0.5 to 1.5 was set, except for items 60 and 61. Only item 60 did not fit into this interval. The fact that the most difficult item 61 fit the selected model refuted the first hypothesis, H1: The most difficult item will not fit the selected model in the created assessment tool. The second hypothesis, H2: The second most difficult item (item 60) will not fit the selected model in the created assessment tool, was confirmed, as the second most difficult item indeed did not fit the selected model according to the values obtained. However, the item was retained in the tool. The p-values were also verified with the condition of values higher than 0.05.

The chi-square values, degrees of freedom, significance level, outfit and infit mean square, and outfit and infit t-values are presented in Table 14 – Absolute Fit: Assessment Tool. Values that reject the first hypothesis and confirm the second hypothesis are in bold and colour.

```
## Itemfit Statistics:
##           Chisq  df p-value Outfit MSQ Infit MSQ Outfit t Infit t
## Item.3  309.398 314   0.563      0.982     1.035     0.20    0.36
## Item.7  183.987 314   1.000      0.584     0.844    -1.26   -1.62
## Item.10 190.579 314   1.000      0.605     0.857    -1.85   -1.73
## Item.12 267.413 314   0.973      0.849     1.013    -0.49    0.17
## Item.20 344.499 314   0.114      1.094     0.982     0.45   -0.17
## Item.39 336.555 314   0.183      1.068     1.016     0.37    0.24
## Item.40 250.057 314   0.997      0.794     0.940    -0.65   -0.74
## Item.49 217.735 314   1.000      0.691     0.784    -0.91   -2.34
## Item.52 299.655 314   0.710      0.951     1.034     0.05    0.36
## Item.60 100.474 314   1.000      0.319     0.625    -0.97   -3.72
## Item.61 206.091 314   1.000      0.654     0.816     0.08   -1.28
## Item.62 264.629 314   0.980      0.840     0.887    -0.75   -1.48
## Item.63 321.244 314   0.377      1.020     0.988     0.16   -0.13
## Item.67 319.075 314   0.410      1.013     0.938     0.13   -0.80
## Item.68 253.077 314   0.995      0.803     0.945    -0.67   -0.68
## Item.71 256.702 314   0.992      0.815     1.070    -0.49    0.85
## Item.72 307.269 314   0.596      0.975     1.256     0.12    2.27
```

Table 14 – Absolute Fit: Assessment Tool (chisq – chi-square; df – degree of freedom; MSQ – mean square)

Finally, the Guttman error was analysed. Plot 5 – Guttman Error shows that 2 out of 3 (almost 250 out of 357) participants have no Guttman error. The high resistance is also confirmed by the calculated index H = 0.691 and the standard error 0.021.



Plot 5 - Guttman Error

The values of the individual items are shown in Table 15 – Guttman Error, Items. The table marks the h-values in bold and colour, showing that all the values are well above 0.5, with the lowest h-value for item 39 being 0.648. Based on these values, we can build the assessment tool into a Guttman scale as originally intended and start using it. The results of the players using the assessment tool will serve to estimate their level of the latent trait of puck control in ice hockey.

H-Index:

## Item number	h-values	std.err
## Item.3	**0.734**	0.043
## Item.7	**0.730**	0.030
## Item.10	**0.704**	0.028
## Item.12	**0.666**	0.033
## Item.20	**0.662**	0.033
## Item.39	**0.648**	0.031
## Item.40	**0.686**	0.029
## Item.49	**0.736**	0.029
## Item.52	**0.703**	0.036
## Item.60	**0.851**	0.026
## Item.61	**0.830**	0.043
## Item.62	**0.691**	0.028
## Item.63	**0.655**	0.031

## Item.67	0.659	0.032
## Item.68	0.665	0.032
## Item.71	0.659	0.034
## Item.72	0.673	0.038

Table 15 – Guttman Error, Items

Rasch model was used to create an assessment tool for puck control skills in ice hockey. This tool, which includes 17 items, was compiled into a Guttman scale based on the difficulty of the items and was further used to set standards for two-year cohorts in ice hockey in the Czech Republic. Thus, the first aim of our work, the creation of a tool for assessing an individual's skill in ice hockey, was achieved. The order of items on the scale from the easiest to the hardest and the resulting assessment tool are shown in Table 16 – Assessment Tool. It also answered the first research question of the thesis: Which puck control skills should ice hockey players have mastered by the age of fifteen? An item bank of 74 items that players should master was created, and then an assessment tool was developed using 17 of the 74 items. The items cover the full range of the latent trait and define the skills that players should master in the area of puck control by the age of fifteen.

Assessment Tool:

## Item number	beta value
## Item.3	2.90
## Item.72	2.35
## Item.52	2.16
## Item.7	1.62
## Item.49	1.51
## Item.12	1.05
## Item.20	0.81
## Item.10	0.71
## Item.62	0.09
## Item.63	-0.28
## Item.39	-0.59
## Item.67	-0.82
## Item.68	-1.17
## Item.40	-1.34
## Item.71	-1.56

```
## Item.60          -3.27
## Item.61          -4.16
```

Table 16 – Assessment Tool

5.13 Defining Standards

Once the assessment tool had been developed, data collection was undertaken to establish standards. The selection of clubs for data collection adhered to the same procedure as for item calibration. The aim was to obtain as many participants as possible for each age cohort. Based on practical experience and the practical application of the defined standards, the age cohorts were defined in a two-year interval, so that players covering an age span of two years were included in a team. Accordingly, standards were defined for players up to the ages of seven, nine, eleven, thirteen, and fifteen; by which the second research question will be answered.

The original target of 200–400 participants between the ages of 6 and 15 was significantly exceeded. Eventually, data were collected from as many as 1 102 participants aged 6–15 years, with the different age cohorts equally represented with approximately 200 participants per cohort.

For the 6–7-year cohort (U7), data were obtained from 180 participants. On average, players in this category in the Czech Republic completed 0.96 items, the median was 0 items, and the standard deviation was 1.25 items. Table 17 – U7 Standards shows the number of players who completed each item, or their level of skill in puck control, out of the 180 participants in the U7 cohort. The table indicates that 92 participants in the U7 category did not complete any item, but 7 participants completed 5 items.

```
## Standards
## Passed items             number of participants
## 0                        92
## 1                        33
## 2                        40
## 3                         7
## 4                         1
## 5                         7
## 6                         0
## 7                         0
## 8                         0
```

## 9	**0**
## 10	**0**
## 11	**0**
## 12	**0**
## 13	**0**
## 14	**0**
## 15	**0**
## 16	**0**
## 17	**0**
## Total participants	**180**
## Mean	**0.96**
## Median	**0**
## Standard deviation	**1.25**

Table 17 – U7 Standards

For the 8–9-year cohort (U9), data were obtained from 253 participants. On average, players in this category in the Czech Republic completed 2.15 items, with a median of 2 and a standard deviation of 1.9 items. Table 18 – U9 Standards lists the number of players who completed each item, out of the 253 participants in the U9 cohort. The table illustrates that 47 participants did not complete any item, but 1 participant under the age of nine was able to complete 11 items.

Standards

## Passed items	number of participants
## 0	**47**
## 1	**54**
## 2	**73**
## 3	**31**
## 4	**25**
## 5	**6**
## 6	**8**
## 7	**4**
## 8	**1**
## 9	**3**
## 10	**0**
## 11	**1**
## 12	**0**
## 13	**0**

## 14	0
## 15	0
## 16	0
## 17	0
## Total participants	253
## Mean	2.15
## Median	2
## Standard deviation	1.9

Table 18 – U9 Standards

For the 10–11-year cohort (U11), data were collected from 266 participants. On average, players in this category in the Czech Republic completed 4.56 items, the median was 4, and the standard deviation was 3.24 items. Table 19 – U11 Standards shows the number of players who completed each item, i.e., their skill level in puck control. There are still 22 subjects who were not able to complete even a single item, but 2 players already managed to complete item 14.

Standards

## Passed items	number of participants
## 0	22
## 1	36
## 2	31
## 3	25
## 4	34
## 5	11
## 6	35
## 7	14
## 8	20
## 9	23
## 10	2
## 11	8
## 12	2
## 13	1
## 14	2
## 15	0
## 16	0
## 17	0

## Total participants	266
## Mean	4.56
## Median	4
## Standard deviation	3.24

Table 19 – U11 Standards

For the cohort aged 12–13 years (U13), data were gathered from 221 participants. On average, players in this category in the Czech Republic completed 5.73 items, with a median of 6 and a standard deviation of 3.3. Accordingly, Table 20 – U13 Standards captures the number of players who completed each item, or their level of skill in puck control, out of the 221 participants in the U13 cohort. The table shows that there are still players in this category who did not fulfil any of the items, namely, 8 players. The 3 best participants were able to complete 13 items.

Standards

## Passed items	number of participants
## 0	8
## 1	21
## 2	20
## 3	18
## 4	20
## 5	11
## 6	31
## 7	10
## 8	29
## 9	29
## 10	5
## 11	14
## 12	2
## 13	3
## 14	0
## 15	0
## 16	0
## 17	0
## Total participants	221
## Mean	5.73

## Median	6
## Standard deviation	3.3

Table 20 – U13 Standards

For the 14–15-year cohort (U15), data were obtained from 182 participants. On average, players in this category in the Czech Republic completed 8.2 items; the median was 9, and the standard deviation was 3.25 items. Table 21 – U15 Standards lists the number of players who completed each item in the U15 cohort. There was still 1 player out of 182 in the cohort who did not complete any item, and no player was able to successfully complete all 17 items.

Standards

## Passed items	number of participants
## 0	1
## 1	5
## 2	8
## 3	13
## 4	4
## 5	3
## 6	12
## 7	9
## 8	26
## 9	38
## 10	13
## 11	31
## 12	11
## 13	1
## 14	5
## 15	1
## 16	1
## 17	0
## Total participants	182
## Mean	8.2
## Median	9
## Standard deviation	3.25

Table 21 – U15 Standards

This has set the standards for the puck control in ice hockey in the Czech Republic.

5.14 Summary of Defining Standards

Based on data collected from 1 102 subjects, we defined puck control standards in ice hockey for cohorts of players aged 6–15 years. The subjects were divided into cohorts in two-year intervals, creating cohorts of 6–7 years, 8–9 years, 10–11 years, 12–13 years, and 14–15 years. For each cohort, data were collected from approximately 200 participants to ensure a comparable sample size of participants for each cohort.

The standards set for each cohort are as follows: out of a total of 17 items, 0 items for the 6–7-year cohort, 2 items for the 8–9-year cohort, 4 items for the 10–11-year cohort, 6 items for the 12–13-year cohort, and 9 items for the 14–15-year cohort.

The results are as expected for the youngest players, who are only starting to play ice hockey and acquire skills. A breakthrough starts with the cohort of 10–11-year-olds, when the training of players in this category should theoretically focus on skating and puck control. However, the improvement is linear, and the results do not show a large increase in skills, which is a continuing tendency for the 12–13-year cohort.

From the results it can be concluded that the skill level of the players does not reach the expected level, both for the 12–13-year cohort and especially for the 14–15-year cohort. Players in the oldest cohort observed should have already mastered all puck control skills at their age. However, according to our research, their performance or the level of their latent trait is not at the highest level. On the contrary, it is somewhere in the middle of the scale.

6 DISCUSSION

A total of 17 items were selected for our assessment tool. Based on the calibration, 24 items fit the Rasch model. In our opinion, however, it was appropriate to reduce the number of items in view of the subsequent use in practice. A smaller number of items indicating the skill level of the player is more suitable for coaches. In addition, the items retained in the tool cover almost the entire range of difficulty and will therefore optimally reflect the level of the latent trait. Some of the discarded items differed only minimally in difficulty from the selected items, so their discriminative value would be negligible compared to the selected items. During calibration it also became apparent that some eventually discarded items were more demanding in terms of preparation, explanation, and overall test administration than the selected items, while their difficulty was similar to that of the retained items. Therefore, we believe that the number of 17 selected items is appropriate for use in the assessment tool.

The statistical environment chosen for the item analysis was R. Although there are numerous other programs and environments on the market that handle item response analysis and also focus on the Rasch model, the environment we chose offers all the statistical calculations we needed, as well as their graphical output. To use the R environment, knowledge of the necessary commands to enter the calculation is required. A precise, specific command must be entered for the required calculations, as in programming, so the environment is more difficult to use than other software that performs calculations based only on entering basic information about the data, but it also provides more complex results. Furthermore, the environment has the advantage that the calculations can target a specific part of the data, so it is not necessary to edit and reload the data separately. The environment also provides a help manual with useful examples. Due to the current widespread use of the R environment in many fields, many additional tutorials and examples can be found on the internet. In our opinion, the R environment is therefore suitable for performing such calculations and data analysis as ours.

The Rasch model was chosen for the development of the assessment tool. It is usually recommended in the literature as the simplest model of item response theory for the development of assessment tools (Čepička, 2003; Dragounova, 2018). Due to the nature of the items created for the item bank, the three-parameter model was rejected at the outset. The items were created in such a way that random guessing was not possible or a successful attempt had to be repeated. The two-parameter model was rejected because the number of items was large enough and because we used items that only had to indicate the participant's level of the latent trait, so that the discriminative ability of the items was not important for our instrument. The decision to use a one-parameter model or a Rasch model was then based on the literature (de Ayala, 2009; Linacre, 2002) and the principles underlying the one-parameter and Rasch models. The one-parameter model is used in situations where the model fits the data. The Rasch model is then used to construct tests, and items that do not fit the model tend to be removed from the bank. However, this requires a sufficiently large item bank. All these requirements have been met. Therefore, in our opinion, the use of the Rasch model in our research is appropriate and its use in similar research can be further recommended.

In the process of calibrating the item bank for the purpose of the assessment tool, we discarded items that did not fit the Rasch model. This was done in the first seven rounds of selection based on the outfit mean square and infit mean square statistics, with values in the range of 0.5 to 1.5 being recommended for the development of the assessment tool. Scores above 1.5 are unproductive for assessment tool development, and scores below 0.5 are less productive but not degrading (Linacre, 2003). Based on the analysis, items 60 and 61 were found to be the most difficult. However, their outfit and infit mean square values during calibration were always at the lower end of the interval recommended for assessment tool development. Due to their difficulty and subsequent use in the assessment tool, and therefore their practical contribution, it was decided that as long as the items did not have extreme values, they would be retained in the item bank, even though their outfit and infit values were not within the interval. During calibration, items 60 and 61 were at the lower end of the interval, with item 60 more likely to have lower outfit values. We attribute the low outfit mean square values to the fact that only a small proportion of participants were able to complete the items during calibration. We will subsequently use this in the assessment tool we are developing, with items 60 and 61 being the most difficult and thus providing optimal feedback for coaches and players around the age of 15, when much of the selection of players in their future hockey careers will take place. For these reasons, items 60 and 61 were retained in the item bank and subsequently in the assessment tool, even though their outfit and infit mean square values at certain stages of the selection rounds and the choosing of items for the assessment tool indicated that the items should be discarded. In our opinion, the inclusion of items 60 and 61 in the assessment tool will only have a positive effect in practice, justifying their inclusion in the assessment tool despite their not entirely satisfactory scores due to their high difficulty.

During calibration and data analysis, the use of the Rasch model revealed an anomaly where the test had a high reliability but also a high standard error with low test information. However, this anomaly was explained by constraining the value of the discriminant parameter to a value of one. It is the value of one that is specific to the Rasch model and thus distinguishes it from the one-parameter model. Mathematically, then, the models are identical. As soon as we removed this "constraint", the standard error of the test decreased and the test information increased, corresponding to the high reliability. To verify our explanation, we also used Mokken analysis to test our data. The results then matched ours during each round of the assessment tool development. Violations of the requirements for the Mokken analysis were gradually eliminated. For the developed assessment tool, the values of the Mokken analysis also confirmed the chosen procedure and the results obtained.

To assess reliability, we decided to use Cronbach's alpha, as in Martínková and Zvara (2007), Christmann and Van Aelst (2006), and McNeish (2018). However, Sijtsma and Molenaar (2002) report that Cronbach's alpha can be affected, whereas the rho-coefficient calculated using Mokken analysis is almost free from side effects. We therefore decided to use both coefficients to assess reliability. As mentioned above, the Mokken analysis also helped us to explain the low test information anomaly. Cronbach's alpha increased over the rounds of selection and elimination of nonconforming items, and the rho-coefficient also increased as the prerequisites for using Mokken analysis were met. The values then approached a value of one for the developed assessment tool. Since the two coefficients used were in agreement based on the analyses carried out, we can conclude that the test is consistent and that both coefficients are suitable for assessing reliability in similar research.

The second aim of our work was to define standards in terms of puck control in ice hockey in the Czech Republic. The standards were defined for players aged up to 7 years (U7), up to 9 years (U9), up to 11 years (U11), up to 13 years (U13), and up to 15 years (U15). Based on practical requirements, the standards have not been defined for each year corresponding to the age of the players but, instead, for a cohort of players within a two-year age span, where in practice players in youth competitions can play with players one year older. Also, in practice, the differences in the level of mastery of the skill of puck control among players one year older or younger are not great, especially at the beginning of systematic training, so the contribution of the results obtained in this way to practice would be minimal. Therefore, in our opinion, it is appropriate for our work and for use in practice to define standards for individual cohorts at an interval of two years, and this division can be recommended for research on similar topics.

As mentioned in the introduction to our work, there are numerous skills required in ice hockey. One of the basic skills, puck control, was selected to create an assessment tool. In practice and in the literature, it is recommended to start the systematic acquisition of the skill at the turn of preschool and early school age, while the skill should be fully mastered at the age of 15 (Hockey Canada, 2018; USA Hockey, 2024; Český hokej, 2018). When selecting the skill, it was also taken into account that there are no scientifically rooted tests of ice hockey skills in the literature, nor are they used by coaches in practice. It was also necessary to consider the fact that we were not only creating a test but also had to prepare a methodology for creating tests of ice hockey skills. Therefore, it was necessary to choose a skill for which it would be possible to clearly decide whether an item had been passed successfully or not, not only for the purposes of our work. As we are creating the first scientifically based test in ice hockey, we also wanted to make it as easy as possible to use and apply in practice. The puck control skill was chosen for the above reasons.

When evaluating the skill of puck control, we had to ignore (i.e., not score) the quality of skating. This was due to the requirement of simplicity of the practical application and also for calibration and data processing purposes. Although we do not doubt that the skating ability is a prerequisite for hockey players, for the purposes of our work, we had to disregard this skill. Instead, we based our evaluation of the players on the fact that, just as the difficulty of the items created increases with the length of time the players are trained in puck control, so too should the players improve their skating skills. Although there are items that involve movement and require skating to complete them, and the maximum possible intensity of movement is required, it is only the skill of puck control that is assessed. Skating technique, quality, or fluidity of movement is not assessed. We also assumed that the assessment tool was designed for players aged 6 to 15 and that their skills would naturally be different.

It can also be argued that especially in today's hockey, speed of movement and acceleration are essential. In this case, the ability to shoot or pass immediately after stick handling around the opponent/defender ("fake-pull") would also have to be taken into account. However, these are other fundamental skills, and it is necessary to prepare tests specifically for them and then evaluate whether it is possible to create a test for all the skills at the same time. In addition, the definition of the cut-off points for the assessment itself would be very difficult and hardly controllable in practice. In practice, then, as we collected data to set the standards, it became clear that when players did not have sufficient skill, they were often unable to complete the items even at a leisurely pace, let alone at maximum intensity. We acknowledge that in the ideal case, it would be useful to combine all skills into a whole, based on game situations in the game. However, in our opinion, it is unrealistic to expect such an assessment tool to be scientifically based, and the question arises as to whether a complete expert assessment in games would not be preferable for such a purpose. It was also not the intention of our research to replace such an assessment.

7 CONCLUSION

In the zero phase of our research, a systematic review of the literature was conducted, which confirmed that no scientifically based assessment tool for ice hockey skills was available in practice or in the literature.

After confirming this initial hypothesis, a 74-item puck control skill item bank was created based on the literature review and interviews with experts in the field of ice hockey.

Data collection and calibration of the item bank was then carried out. The items were calibrated and validated using data obtained from 357 participants. In seven rounds of elimination, items that did not fit the Rasch model were gradually removed from the item bank.

In the first selection round, 23 items that did not fit the Rasch model were removed from the item bank. In the second round, 9 items were removed; in the third round, 6 items were removed; in the fourth round, 3 items were removed; in the fifth round, 7 items were removed; and in the sixth selection round, all items already fit the Rasch model. Subsequently, the correlation between the items was checked and based on p-values, two further items were removed in the seventh round. In the eighth round, the process continued with choosing items for the assessment tool, with 18 items selected out of 24. The eliminated items were not included mainly due to the complexity of the design (which would make it difficult for the trainers to administer the items in practice) and yet minimal difference in the level of difficulty. In the last, eighth round, one more item was excluded due to its correlation with other items based on p-values. Thus, our assessment tool contains 17 items.

Using the Guttman scale, the items were ranked from the easiest to the most difficult. This fulfilled the first aim of our work and answered the first research question (i.e., which puck control skills should ice hockey players have mastered by the age of fifteen). At the same time, hypothesis H1 was rejected (i.e., the hypothesis that the most difficult item will not fit the selected model in the created assessment tool), and hypothesis H2 was confirmed (i.e., the hypothesis that the second most difficult item will not fit the selected model in the created assessment tool).

The 17-item assessment tool developed and compiled in this way was used to define standards in terms of puck control for ice hockey players aged 6–15 years in the Czech Republic for cohorts of 6–7 years, 8–9 years, 10–11 years, 12–13 years, and 14–

15 years. This also fulfilled the second aim of our thesis and answered the second research question of our thesis (i.e., what are the standards of puck control in each age category of ice hockey).

To define the standards, data were collected from participants in hockey clubs selected from across the Czech Republic, whereby the conditions for selecting clubs and participants were the same for the whole research period (calibration and standards). A total of 1 102 participants took part in the tests, and only the time aspect of the research (delay in data collection due to the COVID-19 pandemic) prevented an even larger participation of respondents. Thus, the planned sample size was exceeded several times, confirming the expected interest of hockey clubs in the assessment tool and increasing the relevance of our results.

Based on the results of our work and the defined standards in puck control in ice hockey for players aged 6–15 years, we can conclude that the player' skills are at an insufficient level, which corresponds to the assessment of coaches not only of youth national teams. Only a very small percentage of players reached at least the level of the last four items. Only a few individuals had the opportunity to try to achieve the last two items. For further use of the tool in practice, it would be useful to secure data from players from other hockey-developed countries in Europe and overseas, once the COVID-19 measures are lifted.

The methodology developed to create the assessment tool for puck control in ice hockey can also be utilised to prepare assessment tools for other skills. In our opinion, it can also be used in other sports games.

The results of this work will be made available to methodologists and coaches of the Czech Ice Hockey Association, as well as to coaches in clubs, the International Ice Hockey Federation, and individual national associations and federations. We believe that they will contribute to the development of the training process of players and the education of ice hockey coaches, not only in youth categories.

The results of the work will also help to improve the process of motor learning, obtaining feedback, and streamlining the training process in youth categories and beyond.

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9 ANNEXES

Appendix 1 - Ethics Committee Request

UNIVERZITA KARLOVA
FAKULTA TĚLESNÉ VÝCHOVY A SPORTU
José Martího 31, 162 52 Praha 6-Veleslavín

Žádost o vyjádření Etické komise UK FTVS

k projektu výzkumné, kvalifikační či seminární práce zahrnující lidské účastníky

Název projektu: Diagnostika herních činností jednotlivce hráčů ledního hokeje na příkladu uvolňování hráče s kotoučem
Forma projektu: výzkumná práce - doktorská práce
Období realizace: 03/2019 – 09/2020
Předkladatel: Lukáš, Chmelíř, Mgr., UK FTVS, katedra pedagogiky, psychologie a didaktiky TV a sportu
Hlavní řešitel: Lukáš, Chmelíř, Mgr., UK FTVS, katedra pedagogiky, psychologie a didaktiky TV a sportu
Místo výzkumu (pracoviště): výzkum bude probíhat na zimních stadionech po celé ČR; v klubech, které zastřešují všechny věkové kategorie pro hráče ve věku 5 – 15 let a ti podstupují tréninkové dávky dle doporučení ČSLH; kluby budou vybírány dle daných kritérií a dle ochoty se do výzkumu zapojit; výsledky budou zpracovávány na katedře pedagogiky, psychologie a didaktiky TV a sportu UK FTVS
Vedoucí práce (v případě studentské práce): doc. PaedDr. Tomáš Perič, Ph.D.

Popis projektu: Cílem práce bude vytvoření nástroje k diagnostice herních činností jednotlivce v ledním hokeji a následně pomocí tohoto nástroje pro hráče ledního hokeje definovat standardy v oblasti uvolňování hráče s kotoučem. Bude využito metod pozorování hráčů ledního hokeje a terénního testování na ledě. Probandi budou na základě vytvořených testových položek hodnoceni na škále ano/ne (splnil/nesplnil). Tréninkový proces nebude součástí testování - za bezpečnost cvičení a jeho realizaci nadíž bude zodpovídat trenér. Po dohodě s trenéry bude daná tréninková jednotka - uvolňování hráče s kotoučem, kdy budou probandi podstupovat jednotlivá cvičení na kontrolu kotouče - (75 min.) upravena a bude sloužit také pro účely testování. Předpokládáme, že za danou tréninkovou jednotku otestujeme jeden tým (cca 20 probandů). Probandi i hodnotitele budou před začátkem testováním poučeni o správném provedení (případně nesprávném), hráči pak budou poučováni i během testování. Předpokládáme, že testování bude prováděno v průběhu sezon 2018-2019 a 2019-2020.
Charakteristika účastníků výzkumu: Předpokládaný počet účastníků je 300 – 500 probandů ve věku 5 – 15 let. Při výběru probandů se bude postupovat dle kritérií kalendářního věku a zároveň také sportovního věku. Probandi budou muset splňovat obě kritéria, přičemž kritérium sportovního věku nesmí být přerušeno, ani nijak ovlivněno vzhledem k ostatním probandům (přerušení soustavné tréninkové činnosti, vyjma běžných nemocí). Probandi musí podstupovat tréninkové dávky (délka a počet tréninkových jednotek týdně, náplň tréninků) dle doporučení metodických materiálů ČSLH pro dané věkové období. Probandi budou vybíráni pouze z klubů, které zastřešují všechny mládežnické kategorie po kategorii mladší dorost.
Zajištění bezpečnosti: V průběhu testování budou probandi pod dohledem zkušených trenérů, minimálně držících trenérskou licenci „B". Probandi nebudou vystavováni žádným kontaktům, před zahájením testování budou řádně rozcvičeni a poučeni o provedení. Budou využívány neinvazivní metody. Rizika prováděného výzkumu nebudou vyšší než běžně očekávaná rizika u aktivit a testování prováděných v rámci tohoto typu výzkumu.
Etické aspekty výzkumu: Výzkum zahrnuje vulnerabilní skupinu nezletilých osob, protože výsledky povedou k prohloubení problematiky vývojových zákonitostí a teorie motorického učení. Také přispějí k vytvoření metodického materiálu pro trenéry ledního hokeje a zefektivnění zdokonalování hráčů. Získaná data budou zpracovávána a bezpečně uchovávána v anonymní podobě a publikována v disertační práci, případně v odborných časopisech, monografiích a prezentována na konferencích, případně budou využita při další výzkumné práci na UK FTVS. Po anonymizaci budou osobní data smazána. Během výzkumu nebudou pořizovány žádné fotografie ani videozáznamy.
V maximální možné míře zajistím, aby získaná data nebyla zneužita.
Text informovaného souhlasu: přiložen

Povinností všech účastníků výzkumu na straně řešitele je chránit život, zdraví, důstojnost, integritu, právo na sebeurčení, soukromí a osobní data zkoumaných subjektů, a podniknout k tomu veškerá preventivní opatření. Odpovědnost za ochranu zkoumaných subjektů leží vždy na straně řešitele, nikoy na zkoumaných, byť dali svůj souhlas k účasti na výzkumu. Všichni účastníci výzkumu na straně řešitele musí brát v potaz etické, právní a regulační normy a standardy výzkumu na lidských subjektech, které platí v České republice, stejně jako ty, jež platí mezinárodně.
Potvrzuji, že tento popis projektu odpovídá návrhu realizace projektu a že při jakékoli změně projektu, zejména použitých metod, zašlu Etické komisi UK FTVS revidovanou žádost.

V Praze dne: 6.10.2018 Podpis předkladatele:

Vyjádření Etické komise UK FTVS

Složení komise: Předsedkyně: doc. PhDr. Irena Parry Martínková, Ph.D.
Členové: prof. PhDr. Pavel Slepička, DrSc.
doc. MUDr. Jan Heller, CSc.
PhDr. Pavel Hráský, Ph.D.
Mgr. Eva Prokešová, Ph.D.
MUDr. Simona Majorová

Projekt práce byl schválen Etickou komisí UK FTVS pod jednacím číslem: 181/2018

dne: 12.10.2018

Etická komise UK FTVS zhodnotila předložený projekt a neshledala žádné rozpory s platnými zásadami, předpisy a mezinárodní směrnicemi pro provádění výzkumu zahrnujícího lidské účastníky.

UNIVERZITA KARLOVA
Fakulta tělesné výchovy a sportu
José Martího 31, 162 52 Praha 6
– 20 –

Řešitel projektu splnil podmínky nutné k získání souhlasu Etické komise.

razítko UK FTVS podpis předsedkyně EK UK FTVS

Appendix 2 - Informed Consent

UNIVERZITA KARLOVA
FAKULTA TĚLESNÉ VÝCHOVY A SPORTU
José Martího 31, 162 52 Praha 6-Veleslavín

INFORMOVANÝ SOUHLAS

Vážený pane, vážená paní,

v souladu se Všeobecnou deklarací lidských práv, zákonem č. 101/2000 Sb., o ochraně osobních údajů a o změně některých zákonů, ve znění pozdějších předpisů a dalšími obecně závaznými právními předpisy *(jakož jsou zejména Helsinská deklarace, přijatá 18. Světovým zdravotnickým shromážděním v roce 1964 ve znění pozdějších změn (Fortaleza, Brazílie, 2013); Zákon o zdravotních službách a podmínkách jejich poskytování (zejména ustanovení § 28 odst. 1 zákona č. 372/2011 Sb.) a Úmluva o lidských právech a biomedicíně č. 96/2001, jsou-li aplikovatelné)*, Vás žádám o souhlas s účastí Vašeho dítěte ve výzkumném projektu v rámci disertační práce s názvem „Diagnostika herních činností jednotlivce hráčů ledního hokeje na příkladu uvolňování hráče s kotoučem" prováděné na UK FTVS.

1. Cílem práce bude vytvoření nástroje k diagnostice herních činností jednotlivce v ledním hokeji a následně pomocí tohoto nástroje pro hráče ledního hokeje definovat standardy v oblasti uvolňování hráče s kotoučem.
2. Bude využito metod pozorování a terénního testování
3. Využity budou neinvazivními metody.
4. Testování bude prováděno v rámci tréninkových jednotek týmů dané kategorie. Tréninkový proces nebude součástí testování a zodpovídá za něj trenér. Po dohodě s trenéry bude daná tréninková jednotka (75 min.) upravena a bude sloužit také pro účely testování. Předpokládáme, že za danou tréninkovou jednotku - uvolňování hráče s kotoučem, kdy budou probandi podstupovat jednotlivá cvičení na kontrolu kotouče - otestujeme jeden tým (cca 20 probandů). Probandi i hodnotitelé budou před začátkem testováním poučeni o správném provedení (případně nesprávném), hráči pak budou poučováni i během testování. Předpokládáme, že testování bude prováděno v průběhu sezon 2018-2019 a 2019-2020.
5. Během testování budou probandi pod dohledem zkušených trenérů.
6. Rizika prováděného výzkumu nebudou vyšší než běžně očekáváná rizika u aktivit a testování prováděných v rámci tohoto typu výzkumu.
7. Účast vašeho dítěte v projektu je dobrovolná a nebude finančně ohodnocená.
8. Získaná data budou zpracovávána a bezpečně uchována v anonymní podobě a publikována v disertační práci, případně v odborných časopisech, monografiích a prezentována na konferencích, případně budou využita při další výzkumné práci na UK FTVS. Po anonymizaci budou osobní data smazána. Během výzkumu nebudou pořizovány žádné fotografie ani videozáznam.
9. Výsledky přispějí k prohloubení problematiky vývojových zákonitostí a teorie motorického učení. Výsledky práce budou poskytnuty ČSLH a IIHF a povedou k vytvoření metodického materiálu pro trenéry ledního hokeje a zefektivnění zdokonalování hráčů.
10. V maximální možné míře zajistím, aby získaná data nebyla zneužita.

Jméno a příjmení předkladatele a hlavního řešitele projektu: Lukáš Chmelíř Podpis: ....

Jméno a příjmení osoby, která provedla poučení .... Podpis:........................

Prohlašuji a svým níže uvedeným vlastnoručním podpisem potvrzuji, že dobrovolně souhlasím s účastí ve výše uvedeném projektu a že jsem měl(a) možnost si řádně a v dostatečném čase zvážit všechny relevantní informace o výzkumu, zeptat se na vše podstatné týkající se účasti ve výzkumu a že jsem dostal(a) jasné a srozumitelné odpovědi na své dotazy. Byl(a) jsem poučen(a) o právu odmítnout účast ve výzkumném projektu nebo svůj souhlas kdykoli odvolat bez represí, a to písemně Etické komisi UK FTVS, která bude následně informovat předkladatele projektu.

Místo, datum ....

Jméno a příjmení účastníka .... Podpis: ....

Jméno a příjmení zákonného zástupce ....

Vztah zákonného zástupce k účastníkovi .... Podpis: ....

Appendix 3 - Document n. 1 for Ethics Committee Request

UNIVERZITA KARLOVA
FAKULTA TĚLESNÉ VÝCHOVY A SPORTU
José Martího 31, 162 52 Praha 6-Veleslavín

Dokument č. 1 k žádosti o vyjádření Etické komise UK FTVS:

Potvrzení pracoviště o možnosti realizace výzkumného projektu z hlediska bezpečnosti účastníků projektu a o možnosti publikace názvu pracoviště

Dokument pro Etickou komisi UK FTVS

Název pracoviště/obchodní firma:

Odpovědná osoba na pracovišti/statutární zástupce: …………………………………………..

Funkce odpovědné osoby: ………………………………………………

Svým níže uvedeným vlastnoručním podpisem potvrzuji, že na výše uvedeném pracovišti lze realizovat projekt s názvem *„Diagnostika herních činností jednotlivce hráčů ledního hokeje na příkladu uvolňování hráče s kotoučem"*, jemuž bylo Etickou komisí UK FTVS přiděleno *j. č. 181/2018* a jehož hlavním řešitelem je *Mgr. Lukáš Chmelíř*, přičemž tento projekt lze na výše uvedeném pracovišti provést s adekvátním zajištěním bezpečnosti pro všechny účastníky projektu, neboť dané pracoviště bude v průběhu realizace projektu adekvátně vybaveno jak po materiální, tak po odborné stránce, a dále zajistí, aby byly dodrženy etické aspekty výzkumu během realizace výzkumu. Dále potvrzuji, že **souhlasím/nesouhlasím** (*nehodící se škrtněte*) s tím, aby byl název pracoviště/obchodní firmy zveřejněn v rámci publikování výsledků tohoto výzkumu a to i v případě, pokud by měl výsledek výzkumu negativní dopad na pověst pracoviště/obchodní firmy.

V …………..., dne…………

Podpis odpovědné osoby/statutárního orgánu na pracovišti:……………………………

Razítko:

Appendix 4 – Items, Assessment tool items are highlighted in red

Item number	English description	Correct execution (pass)	Incorrect execution (fail)
Item 1	Narrow stickhandling, stationary	Narrow relaxed stickhandling while stationary. Three times forehand touch, three times backhand touch.	Losing the puck, uncontrolled stickhandling (puck on edge), skating to retrieve the puck.
Item 2	Narrow stickhandling, backhand fake, stationary	Narrow stickhandling while stationary, releasing the stick to the backhand (one hand), return. Twice stickhandling, one release, repeat three times. Relaxed, smooth, uninterrupted movement; quality of movement matters more than quantity of repetitions. Focus on releasing the stick to one hand and returning it to both hands.	Losing the puck, uncontrolled stickhandling (puck on edge), skating to retrieve the puck, inability to stretch out the hand with the puck and return it to the body.
Item 3	Narrow stickhandling, forehand fake, stationary	Narrow stickhandling while stationary, releasing the stick to the forehand, return. Twice stickhandling, one release, repeat three times. Relaxed, smooth, uninterrupted movement; quality of movement matters more than quantity of repetitions. Focus on hand movement.	Losing the puck, uncontrolled stickhandling (puck on edge), skating to retrieve the puck, inability to work with the lower hand.
Item 4	Wide stickhandling, stationary	Wide stickhandling while stationary, wider than shoulder width.	Losing the puck, uncontrolled stickhandling (puck on edge), skating to
Item 5	Narrow stickhandling, forward skating	Narrow relaxed stickhandling while skating forward. Three times forehand touch, three times backhand touch, skating as fast as possible.	Losing the puck, uncontrolled stickhandling (puck on edge), changing direction to retrieve the

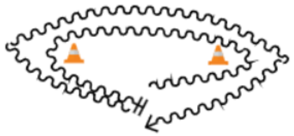
Item number	English description	Correct execution (pass)	Incorrect execution (fail)
			puck, stopping, skating too slow.
Item 6	Narrow stickhandling, backhand fake, forward skating	Narrow stickhandling while skating forward, releasing the stick to the backhand (one hand), return. Twice stickhandling, one release, repeat three times. Relaxed, smooth, uninterrupted movement; quality of movement matters more than quantity of repetitions. Focus on releasing the stick to one hand and returning it to both hands while skating as fast as possible.	Losing the puck, uncontrolled stickhandling (puck on edge), skating to retrieve the puck, inability to stretch out the hand with the puck and return it to the body, changing direction to retrieve the puck, stopping, skating too slow.
Item 7	Narrow stickhandling, forehand fake, forward skating	Narrow stickhandling while skating forward, releasing the stick to the forehand, return. Twice stickhandling, one release, repeat three times. Relaxed, smooth, uninterrupted movement; quality of movement matters more than quantity of repetitions. Focus on hand movement.	Losing the puck, uncontrolled stickhandling (puck on edge), skating to retrieve the puck, inability to work with the lower hand, changing direction to retrieve the puck, stopping, skating too slow, short stickhandling.
Item 8	Wide stickhandling, forward skating	Wide stickhandling while skating forward, wider than shoulder width.	Losing the puck, uncontrolled stickhandling (puck on edge), skating to retrieve the puck, short stickhandling.

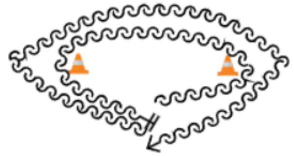
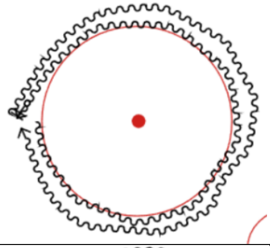
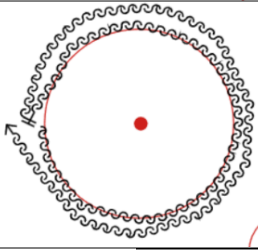
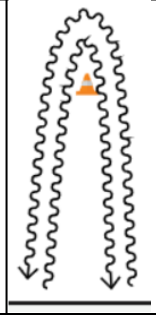
Item number	English description	Correct execution (pass)	Incorrect execution (fail)
Item 9	Narrow stickhandling, backward skating	Narrow relaxed stickhandling while skating backward. Three times forehand touch, three times backhand touch, skating as fast as possible.	Losing the puck, uncontrolled stickhandling (puck on edge), changing direction to retrieve the puck, stopping, skating too slow.
Item 10	Narrow stickhandling, backhand fake, backward skating	Narrow stickhandling while skating backward, releasing the stick to the backhand (one hand), return. Twice stickhandling, one release, repeat three times. Relaxed, smooth, uninterrupted movement; quality of movement matters more than quantity of repetitions. Focus on releasing the stick to one hand and returning it to both hands while skating as fast as possible.	Losing the puck, uncontrolled stickhandling (puck on edge), skating to retrieve the puck, inability to stretch out the hand with the puck and return it to the body, changing direction to retrieve the puck, stopping, skating too slow.
Item 11	Narrow stickhandling, forehand fake, backward skating	Narrow stickhandling while skating backward, releasing the stick to the forehand, return. Twice stickhandling, one release, repeat three times. Relaxed, smooth, uninterrupted movement; quality of movement matters more than quantity of repetitions. Focus on hand movement.	Losing the puck, uncontrolled stickhandling (puck on edge), skating to retrieve the puck, inability to work with the lower hand, changing direction to retrieve the puck, stopping, skating too slow, short stickhandling.
Item 12	Wide stickhandling, backward skating	Wide stickhandling (wider than shoulder width) while skating backward as fast as possible. Repeat three times. Smooth, uninterrupted movement, maintaining control of the puck.	Losing the puck, uncontrolled stickhandling (puck on edge), skating to

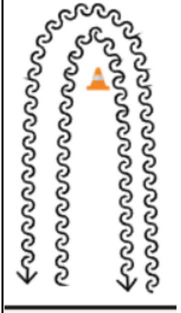
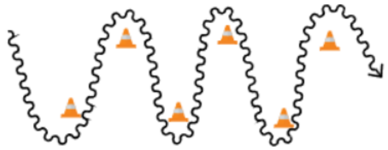
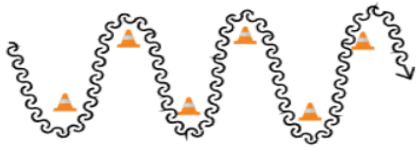
Item number	English description	Correct execution (pass)	Incorrect execution (fail)
			retrieve the puck, short stickhandling.
Item 13	Stickhandling in front of the body, stationary	Stickhandling in front of the body while stationary.	Losing the puck, uncontrolled stickhandling (puck on edge), skating to retrieve the puck, stickhandling outside the body axis.
Item 14	Stickhandling on forehand side, stationary	Stickhandling on the forehand side while stationary.	Losing the puck, uncontrolled stickhandling (puck on edge), skating to retrieve the puck, inability to stickhandle on the forehand side.
Item 15	Stickhandling on backhand side, stationary	Stickhandling on the backhand side while stationary.	Losing the puck, uncontrolled stickhandling (puck on edge), skating to retrieve the puck, inability to stickhandle on the backhand side.
Item 16	Stickhandling behind the body, stationary	Stickhandling behind the body while stationary. The body is turned forward, stickhandling is performed behind the heels.	Losing the puck, uncontrolled stickhandling (puck on edge), skating to retrieve the puck, inability to stickhandle behind the body.

Item number	English description	Correct execution (pass)	Incorrect execution (fail)
Item 17	Stickhandling in front of the body, forward skating	Narrow relaxed stickhandling in front of the body while skating forward. Three times forehand touch, three times backhand touch, skating as fast as possible.	Losing the puck, uncontrolled stickhandling (puck on edge), changing direction to retrieve the puck, stopping, skating too slow, stickhandling outside the body axis.
Item 18	Stickhandling on forehand side, forward skating	Narrow relaxed stickhandling on the forehand side while skating forward. Three times forehand touch, three times backhand touch, skating as fast as possible.	Losing the puck, uncontrolled stickhandling (puck on edge), changing direction to retrieve the puck, stopping, skating too slow, inability to stickhandle on the forehand side.
Item 19	Stickhandling on backhand side, forward skating	Narrow relaxed stickhandling on the backhand side while skating forward. Three times forehand touch, three times backhand touch, skating as fast as possible.	Losing the puck, uncontrolled stickhandling (puck on edge), changing direction to retrieve the puck, stopping, skating too slow, inability to stickhandle on the backhand side.

Item number	English description	Correct execution (pass)	Incorrect execution (fail)
Item 20	Stickhandling behind the body, forward skating	Stickhandling behind the body while skating forward. The body is turned forward, stickhandling is performed behind the heels.	Losing the puck, uncontrolled stickhandling (puck on edge), changing direction to retrieve the puck, stopping, skating too slow, inability to stickhandle behind the body.
Item 21	Stickhandling in front of the body, backward skating	Narrow relaxed stickhandling in front of the body while skating backward. Three times forehand touch, three times backhand touch, skating as fast as possible.	Losing the puck, uncontrolled stickhandling (puck on edge), changing direction to retrieve the puck, stopping, skating too slow, stickhandling outside the body axis.
Item 22	Stickhandling on forehand side, backward skating	Narrow relaxed stickhandling on the forehand side while skating backward. Three times forehand touch, three times backhand touch, skating as fast as possible.	Losing the puck, uncontrolled stickhandling (puck on edge), changing direction to retrieve the puck, stopping, skating too slow, inability to stickhandle on the forehand side while skating backward.
Item 23	Stickhandling on backhand side, backward skating	Narrow relaxed stickhandling on the backhand side while skating backward. Three times forehand touch, three times backhand touch, skating as fast as possible.	Losing the puck, uncontrolled stickhandling (puck on edge), changing direction to retrieve the puck, stopping, skating too

Item number	English description	Correct execution (pass)	Incorrect execution (fail)
			slow, inability to stickhandle on the backhand side while skating backward.
Item 24	Stickhandling standing, kneeling, standing	Maintaining stickhandling while going from standing to kneeling and back. Stationary.	Losing the puck, uncontrolled stickhandling (puck on edge), skating to retrieve the puck, interrupting stickhandling.
Item 25	Pulling the puck, backward skating	Pulling the puck while skating backward.	Losing the puck, stopping, skating too slow, stickhandling.
Item 26	Stopping the puck on B-R-B line while skating forward	Start with the puck 3 m / 10 feet before the blue line. Stop the puck directly on the blue line. Take another puck and stop it on the red line. Take another puck and stop it on the next blue line. Skate as fast as possible, stop skating 2 m / 7 feet behind the blue line. At least 2 out of 3 pucks must remain lying on the line.	Skating too slow, fewer than two of the three pucks on the lines, stopping skating between the lines.
Item 27	Stickhandling between stick and skates of another player	The assisting player stands holding the stick vertically in one hand. Stickhandling is performed between the stick and skates of the assistant; the puck moves under the assistant's stick. Three times forehand touch, three times backhand touch.	Losing the puck, hitting the opponent's stick, slow stickhandling because of the inability to manoeuvre with the stick around objects.
Item 28	Guiding the puck around cones 2 m / 7 feet apart, forward skating (forehand + backhand; Figure 1)	 Cones laid out 2 m / 7 feet apart (see Figure). Guiding the puck around the cones while skating forward as fast as possible. Left + right.	Losing the puck, skating too slow, leaving the track to retrieve the puck.

Item number	English description	Correct execution (pass)	Incorrect execution (fail)
Item 29	Guiding the puck around cones 2 m / 7 feet apart, backward skating (forehand + backhand; Figure 1)	 Cones laid out 2 m / 7 feet apart (see Figure). Guiding the puck around the cones while skating backward as fast as possible. Left + right.	Losing the puck, skating too slow, leaving the track to retrieve the puck.
Item 30	Guiding the puck on the circle, forward skating (forehand + backhand; Figure 2)	 Guiding the puck on the face-off circle while skating forward as fast as possible. Left + right (see Figure).	Losing the puck, skating too slow, leaving the track to retrieve the puck.
Item 31	Guiding the puck on the circle, backward skating (forehand + backhand; Figure 2)	 Guiding the puck on the face-off circle while skating backward as fast as possible. Left + right (see Figure).	Losing the puck, skating too slow, leaving the track to retrieve the puck.
Item 32	Forward skating, skating on a curve, cone 5 m / 16.5 feet away (forehand + backhand; Figure)	 Cone positioned 5 m / 16.5 feet from the start (see Figure). Skating forward with the puck as fast as possible around the cone one way and back, another way and back.	Losing the puck, skating too slow, leaving the track to retrieve the puck.

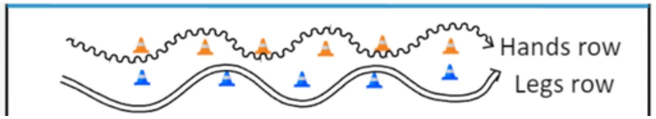
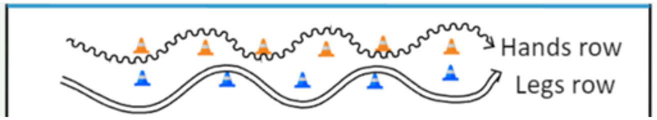
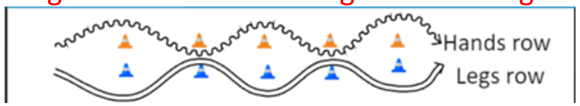
Item number	English description	Correct execution (pass)	Incorrect execution (fail)
Item 33	Backward skating, skating on a curve, cone 5 m / 16.5 feet away (forehand + backhand; Figure 3)	 Cone positioned 5 m / 16.5 feet from the start (see Figure). Skating backward with the puck as fast as possible around the cone one way and back, another way and back.	Losing the puck, skating too slow, leaving the track to retrieve the puck.
Item 34	Semi-circle forward skating, cone slalom one way and back	Five cones positioned in a semi-circle on the face-off circle. Forward slalom skating with the puck around the cones one way and back, as fast as possible. Start on the forehand side to the cone.	Losing the puck, skating too slow, leaving the track to retrieve the puck.
Item 35	Semi-circle backward skating, cone slalom one way and back	Five cones positioned in a semi-circle on the face-off circle. Backward slalom skating with the puck one way and back, as fast as possible. Start on the forehand side to the cone.	Losing the puck, skating too slow, leaving the track to retrieve the puck.
Item 36	Forward skating in curves (6 cones; Figure 4)	Six cones positioned 5 m / 16,5 feet apart (see Figure). Forward slalom skating with the puck around the cones as fast as possible. 	Losing the puck, skating too slow, leaving the track to retrieve the puck.
Item 37	Backward skating in curves (6 cones; Figure 4)	Six cones positioned 5 m / 16,5 feet apart (see Figure). Backward slalom skating with the puck around the cones as fast as possible. 	Losing the puck, skating too slow, leaving the track to retrieve the puck.

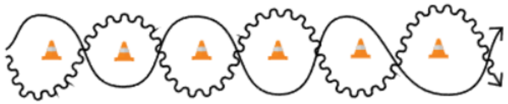
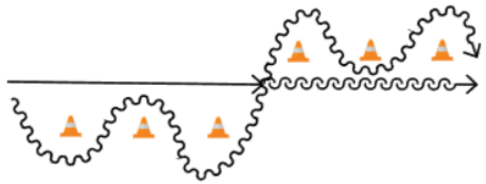
Item number	English description	Correct execution (pass)	Incorrect execution (fail)
Item 38	Stickhandling over lying stick (forehand to backhand; 1 out of 3 attempts)	One stick is lying on the ice. The player is stationary and tosses the puck over the lying stick from forehand to backhand while maintaining control of the puck. At least one out of three attempts.	No successful attempt, skating to retrieve the puck, inability to control the puck.
Item 39	Stickhandling over lying stick (backhand to forehand, 1 out of 3 attempts)	One stick is lying on the ice. The player is stationary and tosses the puck over the lying stick from backhand to forehand while maintaining control of the puck. At least one out of three attempts.	No successful attempt, skating to retrieve the puck, inability to control the puck.
Item 40	Puck pickup with stick, catching by hand (1 out of 3 attempts)	Players must pick up the puck from the ice solely with the stick and catch it. If the player fails to catch the puck due to glove interference (only hits the puck), it is considered a successful attempt. The player needs to achieve this successfully at least once out of three attempts	Inability to pick up the puck from ice, skating to retrieve the flying puck.
Item 41	Sweethands	Relaxed sweethands stickhandling. As fast as possible.	Losing the puck, having the puck stuck at the sweethands bar, stickhandling too slow.
Item 42	Figure eight, skating forward around two cones	Two cones positioned 3 m / 10 feet apart. Skating forward with the puck in a figure-eight shape around the cones, as fast as possible.	Losing the puck, stopping, skating too slow, inability to guide the puck on the blade around the cone.
Item 43	Figure eight, stationary, forehand side from the body	Two low cones (max. 5 cm / 2 inches) positioned so that the player standing in between them, slightly in the front, can reach both with the stick. Guiding the puck around the cones in a figure-eight shape; using forehand on the forehand side and backhand on the backhand side. Repeat three times.	Inability to guide the puck in the figure-eight shape three times in row without stopping, losing the puck, stickhandling too slow.

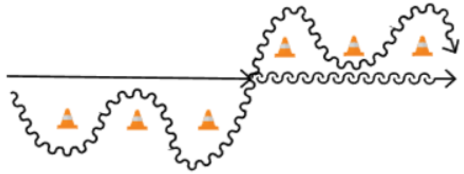
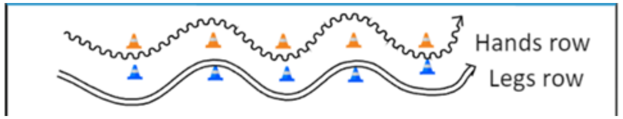
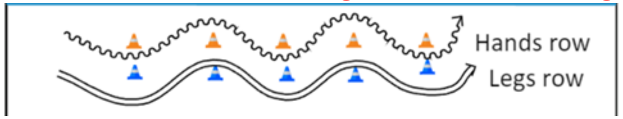
Item number	English description	Correct execution (pass)	Incorrect execution (fail)
Item 44	Figure eight, stationary, forehand side to the body	Two low cones (max. 5 cm / 2 inches) positioned so that the player standing in between them, slightly in the front, can reach both with the stick. Guiding the puck around the cones in a figure-eight shape; using forehand on the backhand side and backhand on the forehand side. Repeat three times.	Inability to guide the puck in the figure-eight shape three times in row without stopping, losing the puck, stickhandling too slow.
Item 45	Puck – stick – kick – stick; stationary	The player passes the puck on his feet and kicks the puck back on the stick. Stationary.	Falling, inability to pass the puck on the stick and kick it back on the stick (losing the puck).
Item 46	Puck – stick – kick – stick; forward skating	The player passes the puck on his feet and kicks the puck back on the stick while skating forward.	Falling, inability to pass the puck on the stick and kick it back on the stick (losing the puck), skating to retrieve the puck
Item 47	Puck – stick – kick – stick; backward skating	The player passes the puck on his feet and kicks the puck back on the stick while skating backward.	Falling, inability to pass the puck on the stick and kick it back on the stick (losing the puck), skating to retrieve the puck.
Item 48	Guiding the puck through the legs, kick, stationary	The player passes the puck through his legs from behind, using an inside-edge kick of the skate to pass the puck on the stick. Stationary.	Failure to pass the puck through the legs, losing the puck, failure to kick the puck.
Item 49	Guiding the puck through the legs, kick, forward skating	While skating forward, the player passes the puck through his legs from behind, using an inside-edge kick of the skate to pass the puck on the stick.	Failure to pass the puck through the legs, losing the puck, failure to kick the puck.

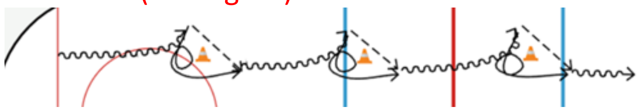
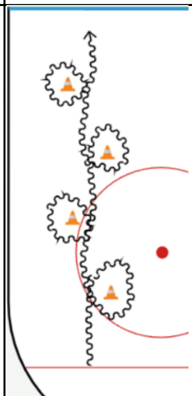
Item number	English description	Correct execution (pass)	Incorrect execution (fail)
Item 50	Guiding the puck through the legs, no kick, stationary	The player passes the puck through his legs from behind and guides it on the stick WITHOUT A KICK. Stationary.	Failure to pass the puck through the legs, losing the puck, kicking the puck.
Item 51	Forward and backward skating around cones, one way and back (5 cones; 5 m / 16.5 feet)	Five cones laid out in the shape of a wave 5 m / 16.5 feet apart. The player faces the top of the wave and slalom skates forward and backward, one way and back.	Losing the puck, stopping, inability to transition from skating forward to skating backward and the other way round.
Item 52	Forehand fake pass, backhand skating away	The player starts stationary, makes a fake pass on the forehand side, moves the puck to the backhand side, and skates away on the backhand side.	Failure to fake pass, losing the puck while making the fake pass or while skating away.
Item 53	Backhand fake pass, forehand skating away	The player starts stationary, makes a fake pass on the backhand side, moves the puck to the backhand side, and skates away on the forehand side.	Failure to fake pass, losing the puck while making the fake pass or while skating away.
Item 54	360-degree turn, left + right, with puck on stick, stationary	A 360-degree turn with the puck on the stick, left and right. Stationary.	Losing the puck, stopping while turning.
Item 55	360-degree turn, left + right, with puck on stick, forward skating	A 360-degree turn with the puck on the stick, left and right, while skating forward.	Losing the puck, stopping while turning, stopping skating.
Item 56	360-degree turn, left + right, with puck on stick, backward skating	A 360-degree turn with the puck on the stick, left and right, while skating backward.	Losing the puck, stopping while turning, stopping skating.

Item number	English description	Correct execution (pass)	Incorrect execution (fail)
Item 57	Forward skating, 360-degree turn without puck (push puck forward), regain control of puck, left + right	The player starts skating forward with the puck, pushes the puck forward, makes a 360-degree turn, and regains control of the puck. Left + right.	Pushing the puck too little or too much and failure to retrieve it, retrieving the puck too late after turning, returning for the puck left behind.
Item 58	Legs straight, hand slalom between cones, forehand side (Figure 5)	Six small cones laid out in a row 1.5 m apart (see Figure). The player skates straight forward along the cones while slalom stickhandling around the cones on the forehand side. 	Losing the puck, irregular slalom stickhandling, skating too slow (failure to skate and stickhandle in the same speed), skating between the cones.
Item 59	Legs straight, hand slalom between cones, backhand side (Figure 5)	Six small cones laid out in a row 1.5 m apart (see Figure). The player skates straight forward along the cones while slalom stickhandling around the cones on the backhand side. 	Losing the puck, irregular slalom stickhandling, skating too slow (failure to skate and stickhandle in the same speed), skating between the cones.
Item 60	Alternate leg and hand slalom, forehand side (Figure 6)	Cones laid out in two rows, 2 meters apart lengthwise, skate-stick blade width apart; six cones for hands, five cones for legs (see Figure). The player slalom skates in the leg row while slalom stickhandling in the hand row on the forehand side. Skating over to the hand row and stickhandling in the leg row are not allowed. This	Losing the puck, skating too slow, missing a cone in the slalom, stickhandling (hands) or skating (legs) in the wrong row.

Item number	English description	Correct execution (pass)	Incorrect execution (fail)
		task necessitates consistent slaloming using legs and stickhandling using hands. 	
Item 61	Alternate leg and hand slalom, backhand side (Figure 6)	Cones laid out in two rows, 2 meters apart lengthwise, skate-stick blade width apart; six cones for hands, five cones for legs (Figure). The player slalom skates in the leg row while slalom stickhandling in the hand row on the backhand side. Skating over to the hand row and stickhandling in the leg row are not allowed. This task necessitates consistent slaloming using legs and stickhandling using hands. 	Losing the puck, skating too slow, missing a cone in the slalom, stickhandling (hands) or skating (legs) in the wrong row.
Item 62	Leg and hand slalom, forehand side, opposite sides (Figure)	Cones laid out in two rows in the shape of a wave, 2 meters apart lengthwise, skate-stick blade width apart; six cones for hands, six cones for legs, positioned 2 m apart (Figure). The player slalom skates while slalom stickhandling on the forehand side. Skating in the stickhandling row and stickhandling in the skating row are not allowed. 	Losing the puck, skating too slow, missing a cone in the slalom, stickhandling (hands) or skating (legs) in the wrong row.
Item 63	Leg and hand slalom, backhand side, opposite sides (Figure)	Cones laid out in two rows in the shape of a wave, 2 meters apart lengthwise, skate-stick blade width apart; six cones for hands, six cones for legs, positioned 2 m apart (see Figure). The player slalom skates while slalom stickhandling on the backhand side. Skating in	Losing the puck, skating too slow, missing a cone in the slalom, stickhandling (hands) or skating (legs) in the wrong row.

Item number	English description	Correct execution (pass)	Incorrect execution (fail)
		the stickhandling row and stickhandling in the skating row are not allowed. 	
Item 64	Leg and hand slalom; legs on one side, hands on the other side of the cone (6 cones; Figure 8)	Six cones in a row 2m apart (see Figure). The player slalom skates around the cones while stickhandling on the opposite side of the cone. When the legs are on the left, the hands are on the right. 	Losing the puck, skating too slow, missing a cone in the slalom, stickhandling (hands) or skating (legs) in the same way.
Item 65	Legs straight forward, hands between cones on forehand side, turn, legs straight backward, hands between cones on forehand side (Figure)	 Cones laid out as in Figure, 2 meters apart lengthwise. The player skates forward, slalom stickhandling on the forehand side; in the middle transitions to skating backward, still stickhandling on the forehand side. Stickhandling starts on the outer side of the cone for skating both forward and backward.	Losing the puck, skating too slow, missing a cone in the slalom, stopping.

Item number	English description	Correct execution (pass)	Incorrect execution (fail)
Item 66	Legs straight forward, hands between cones on backhand side, turn, legs straight backward, hands between cones on backhand side (Figure 9)	Cones laid out as in Figure, 2 meters apart lengthwise. The player skates forward, slalom stickhandling on the backhand side; in the middle transitions to skating backward, still stickhandling on the backhand side. Stickhandling starts on the outer side of the cone for skating both forward and backward. 	Losing the puck, skating too slow, missing a cone in the slalom, stopping.
Item 67	Leg and hand slalom, forehand side, same side (Figure)	Cones laid out in two rows, 2 meters apart lengthwise, skate-stick blade width apart; six cones for hands, six cones for legs, positioned 2 m apart (see Figure). The player slalom skates while slalom stickhandling on the forehand side. Skating in the stickhandling row and stickhandling in the skating row are not allowed. 	Losing the puck, skating too slow, missing a cone in the slalom, stickhandling (hands) or skating (legs) in the wrong row.
Item 68	Leg and hand slalom, backhand side, same side (Figure)	Cones laid out in two rows, 2 meters apart lengthwise, skate-stick blade width apart; six cones for hands, six cones for legs, positioned 2 m apart (see Figure). The player slalom skates while slalom stickhandling on the backhand side. Skating in the stickhandling row and stickhandling in the skating row are not allowed. 	Losing the puck, skating too slow, missing a cone in the slalom, stickhandling (hands) or skating (legs) in the wrong row.
Item 69	Skating with two pucks (middle zone)	The player starts with two pucks on the stick on the blue line and guides both over to the other blue line, as fast as possible.	Losing the puck(s), stopping, changing direction to

Item number	English description	Correct execution (pass)	Incorrect execution (fail)
			retrieve the puck, skating too slow.
Item 70	Skating over obstacles with puck	Skating over four obstacles 10 cm / 4 inches tall. The player jumps over the obstacle while the puck passes under it. The player must touch the puck with the stick between the obstacles.	Falling, failure to control the puck (failure to touch the puck between the obstacles), losing the puck, skating too slow.
Item 71	Forward skating, fake move and pass, 360-degree turn, skating away on the other side, retrieving the puck (three times; Figure 11)	Skating towards a cone, fake move, passing the puck around the cone, 360-degree turn (as if avoiding a defending player). Skating to the other side of the cone, retrieving the puck, and repeating at the next cone (see Figure). 	Losing the puck, stopping, skating too slow, falling, leaving the track to retrieve the puck.
Item 72	Forward skating, tight turn around cone to the left and to the right (two times; Figure 72)	 Cones laid out 3 m apart, as in Figure. The player skates forward with the puck, makes a tight turn around the cone on the left, then a tight turn around the next cone on the right. Repeat two times, as fast as possible (see Figure).	Losing the puck, stopping, skating too slow, falling, leaving the track to retrieve the puck.
Item 73	Pushing the puck (middle zone)	Pushing the puck in the middle zone, as fast as possible.	Losing the puck, stopping, skating too slow.

Item number	English description	Correct execution (pass)	Incorrect execution (fail)
Item 74	Pulling the puck (middle zone)	Pulling the puck in the middle zone, as fast as possible.	Losing the puck, stopping, skating too slow.

Appendix 5– Item Difficulty, Standard Error, Round 1

```
##                     value std.err
## Dffclt.Item.1   -4.0353  0.2671
## Dffclt.Item.2   -1.9999  0.1646
## Dffclt.Item.3   -1.9503  0.1635
## Dffclt.Item.4   -2.0749  0.1665
## Dffclt.Item.5   -3.1241  0.2048
## Dffclt.Item.6   -1.0224  0.1478
## Dffclt.Item.7   -1.0617  0.1483
## Dffclt.Item.8   -1.1012  0.1488
## Dffclt.Item.9   -1.5366  0.1552
## Dffclt.Item.10 -0.4266  0.1421
## Dffclt.Item.11 -0.6628  0.1440
## Dffclt.Item.12 -0.6626  0.1440
## Dffclt.Item.13 -6.0512  0.5963
## Dffclt.Item.14 -4.6235  0.3293
## Dffclt.Item.15 -2.4535  0.1773
## Dffclt.Item.16 -2.0750  0.1665
## Dffclt.Item.17 -4.4282  0.3063
## Dffclt.Item.18 -3.6185  0.2343
## Dffclt.Item.19 -1.6697  0.1576
## Dffclt.Item.20 -0.4987  0.1426
## Dffclt.Item.21 -4.1795  0.2805
## Dffclt.Item.22 -3.0828  0.2027
## Dffclt.Item.23 -1.1410  0.1493
## Dffclt.Item.24 -2.1258  0.1677
## Dffclt.Item.25 -3.5171  0.2275
## Dffclt.Item.26  1.2454  0.1446
## Dffclt.Item.27 -0.9835  0.1473
## Dffclt.Item.28 -3.0070  0.1990
## Dffclt.Item.29 -1.3659  0.1525
## Dffclt.Item.30 -2.4541  0.1773
## Dffclt.Item.31 -0.8686  0.1460
## Dffclt.Item.32 -2.2853  0.1721
## Dffclt.Item.33 -1.6697  0.1576
## Dffclt.Item.34 -2.3127  0.1729
```

```
## Dffclt.Item.35 -0.7929  0.1452
## Dffclt.Item.36 -2.1517  0.1684
## Dffclt.Item.37 -0.6625  0.1440
## Dffclt.Item.38 -0.0585  0.1401
## Dffclt.Item.39  0.5407  0.1397
## Dffclt.Item.40  1.0997  0.1430
## Dffclt.Item.41 -1.4932  0.1545
## Dffclt.Item.42 -4.2572  0.2882
## Dffclt.Item.43 -2.0498  0.1658
## Dffclt.Item.44 -1.5585  0.1556
## Dffclt.Item.45 -2.1262  0.1678
## Dffclt.Item.46 -1.5585  0.1556
## Dffclt.Item.47 -1.1013  0.1488
## Dffclt.Item.48 -1.1211  0.1490
## Dffclt.Item.49 -0.9836  0.1473
## Dffclt.Item.50 -1.3868  0.1528
## Dffclt.Item.51 -1.5585  0.1556
## Dffclt.Item.52 -1.4291  0.1534
## Dffclt.Item.53 -1.1811  0.1498
## Dffclt.Item.54 -0.7741  0.1451
## Dffclt.Item.55 -0.7741  0.1451
## Dffclt.Item.56  0.1135  0.1396
## Dffclt.Item.57 -0.9066  0.1464
## Dffclt.Item.58 -1.7148  0.1585
## Dffclt.Item.59 -1.2623  0.1509
## Dffclt.Item.60  2.5067  0.1742
## Dffclt.Item.61  3.1559  0.2051
## Dffclt.Item.62  0.0281  0.1398
## Dffclt.Item.63  0.3015  0.1394
## Dffclt.Item.64 -0.6444  0.1438
## Dffclt.Item.65  0.2507  0.1394
## Dffclt.Item.66  0.4216  0.1395
## Dffclt.Item.67  0.7126  0.1403
## Dffclt.Item.68  0.9748  0.1419
## Dffclt.Item.69 -2.3402  0.1737
## Dffclt.Item.70 -0.9641  0.1471
```

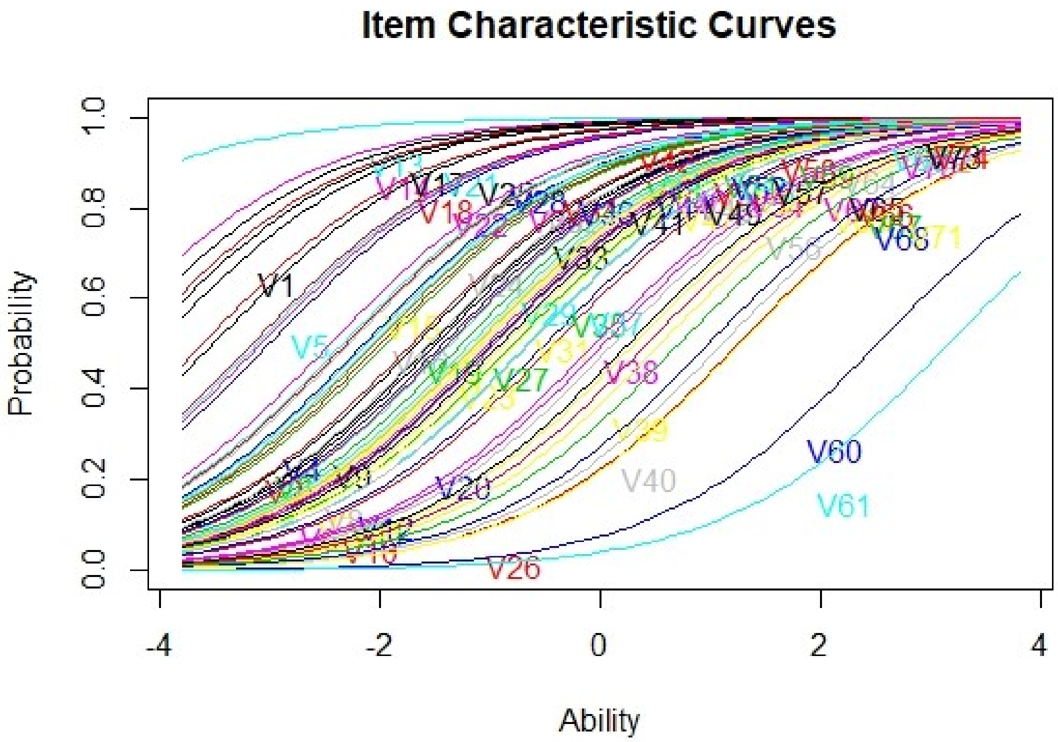
```
## Dffclt.Item.71  1.2638  0.1448
## Dffclt.Item.72 -1.5585  0.1556
## Dffclt.Item.73 -4.1794  0.2805
## Dffclt.Item.74 -3.1625  0.2068
## Dscrmn          1.0000      NA
```

Appendix 6 – Item Difficulty, Conditional Maximum Likelihood, Round 1

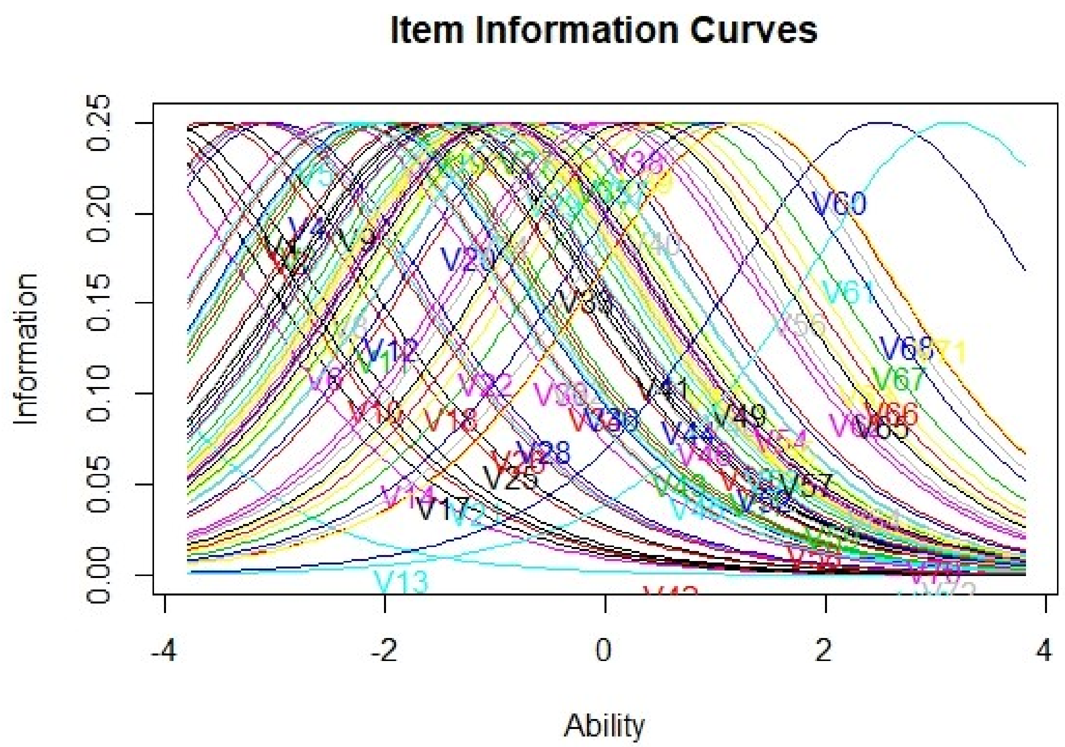
```
## Item Easiness Parameters (beta) with 0.95 CI:
##              Estimate Std. Error lower CI upper CI
## beta Item.1     2.774      0.267    2.251    3.297
## beta Item.2     0.638      0.162    0.320    0.955
## beta Item.3     0.585      0.161    0.270    0.901
## beta Item.4     0.718      0.164    0.397    1.039
## beta Item.5     1.820      0.202    1.424    2.216
## beta Item.6    -0.416      0.146   -0.702   -0.131
## beta Item.7    -0.374      0.146   -0.660   -0.087
## beta Item.8    -0.331      0.147   -0.618   -0.043
## beta Item.9     0.141      0.153   -0.159    0.441
## beta Item.10   -1.066      0.140   -1.340   -0.792
## beta Item.11   -0.809      0.142   -1.086   -0.531
## beta Item.12   -0.809      0.142   -1.086   -0.531
## beta Item.13    4.911      0.605    3.725    6.096
## beta Item.14    3.396      0.333    2.744    4.047
## beta Item.15    1.119      0.174    0.777    1.461
## beta Item.16    0.718      0.164    0.397    1.039
## beta Item.17    3.188      0.308    2.584    3.793
## beta Item.18    2.337      0.232    1.882    2.793
## beta Item.19    0.284      0.155   -0.020    0.588
## beta Item.20   -0.987      0.140   -1.263   -0.712
## beta Item.21    2.926      0.281    2.375    3.476
## beta Item.22    1.779      0.200    1.387    2.171
## beta Item.23   -0.287      0.147   -0.576    0.001
## beta Item.24    0.772      0.165    0.449    1.096
## beta Item.25    2.231      0.225    1.790    2.673
## beta Item.26   -2.893      0.144   -3.176   -2.610
## beta Item.27   -0.459      0.145   -0.743   -0.174
## beta Item.28    1.700      0.196    1.316    2.085
## beta Item.29   -0.044      0.150   -0.338    0.251
## beta Item.30    1.119      0.174    0.777    1.461
## beta Item.31   -0.584      0.144   -0.866   -0.302
## beta Item.32    0.941      0.169    0.609    1.272
## beta Item.33    0.284      0.155   -0.020    0.588
## beta Item.34    0.970      0.170    0.637    1.303
## beta Item.35   -0.667      0.143   -0.947   -0.386
## beta Item.36    0.800      0.166    0.475    1.124
## beta Item.37   -0.809      0.142   -1.086   -0.531
## beta Item.38   -1.468      0.138   -1.738   -1.197
## beta Item.39   -2.121      0.138   -2.391   -1.851
## beta Item.40   -2.733      0.142   -3.012   -2.454
## beta Item.41    0.094      0.152   -0.204    0.393
## beta Item.42    3.008      0.289    2.441    3.575
## beta Item.43    0.691      0.163    0.371    1.011
## beta Item.44    0.165      0.153   -0.136    0.465
## beta Item.45    0.772      0.165    0.449    1.096
## beta Item.46    0.165      0.153   -0.136    0.465
## beta Item.47   -0.331      0.147   -0.618   -0.043
## beta Item.48   -0.309      0.147   -0.597   -0.021
## beta Item.49   -0.459      0.145   -0.743   -0.174
## beta Item.50   -0.021      0.151   -0.316    0.274
```

```
## beta Item.51    0.165       0.153   -0.136    0.465
## beta Item.52    0.025       0.151   -0.271    0.321
## beta Item.53   -0.244       0.148   -0.533    0.045
## beta Item.54   -0.687       0.143   -0.967   -0.407
## beta Item.55   -0.687       0.143   -0.967   -0.407
## beta Item.56   -1.655       0.137   -1.925   -1.386
## beta Item.57   -0.543       0.144   -0.825   -0.260
## beta Item.58    0.333       0.156    0.027    0.639
## beta Item.59   -0.156       0.149   -0.447    0.136
## beta Item.60   -4.273       0.177   -4.621   -3.925
## beta Item.61   -4.958       0.208   -5.366   -4.550
## beta Item.62   -1.562       0.138   -1.831   -1.292
## beta Item.63   -1.860       0.137   -2.130   -1.591
## beta Item.64   -0.829       0.142   -1.106   -0.551
## beta Item.65   -1.804       0.137   -2.074   -1.535
## beta Item.66   -1.991       0.138   -2.260   -1.721
## beta Item.67   -2.309       0.139   -2.581   -2.037
## beta Item.68   -2.596       0.141   -2.872   -2.319
## beta Item.69    0.999       0.171    0.664    1.334
## beta Item.70   -0.480       0.145   -0.764   -0.196
## beta Item.71   -2.913       0.145   -3.197   -2.630
## beta Item.72    0.165       0.153   -0.136    0.465
## beta Item.73    2.926       0.281    2.375    3.476
## beta Item.74    1.861       0.204    1.462    2.261
```

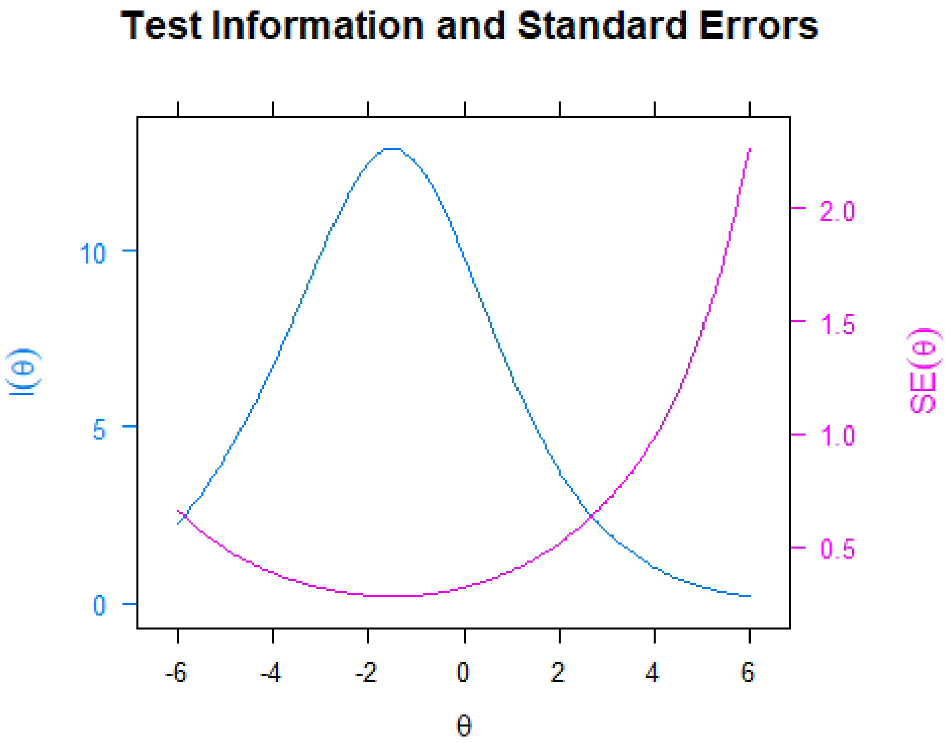
Appendix 7 – Plotted Item Characteristic Curves, Round 1



Appendix 8 – Plotted Item Information Curves, Round 1



Appendix 9 – Plotted Test Information Function, Round 1



Appendix 10 – Unidimensionality, Round 1

```
##              Item H   se
## Item.1     0.353 (0.080)
## Item.2     0.449 (0.036)
## Item.3     0.538 (0.033)
## Item.4     0.469 (0.039)
## Item.5     0.508 (0.052)
## Item.6     0.513 (0.031)
## Item.7     0.572 (0.028)
## Item.8     0.483 (0.034)
## Item.9     0.579 (0.028)
## Item.10    0.621 (0.026)
## Item.11    0.611 (0.026)
## Item.12    0.581 (0.028)
## Item.13    0.529 (0.253)
## Item.14    0.523 (0.123)
## Item.15    0.498 (0.042)
## Item.16    0.528 (0.032)
## Item.17    0.453 (0.121)
## Item.18    0.485 (0.066)
## Item.19    0.491 (0.035)
## Item.20    0.587 (0.030)
## Item.21    0.496 (0.102)
## Item.22    0.213 (0.074)
## Item.23    0.511 (0.032)
## Item.24    0.474 (0.039)
## Item.25    0.379 (0.073)
## Item.26    0.491 (0.040)
## Item.27    0.397 (0.037)
## Item.28    0.436 (0.056)
## Item.29    0.353 (0.040)
## Item.30    0.414 (0.047)
## Item.31    0.472 (0.035)
## Item.32    0.425 (0.046)
## Item.33    0.402 (0.039)
## Item.34    0.409 (0.044)
```

```
## Item.35   0.418 (0.037)
## Item.36   0.515 (0.033)
## Item.37   0.497 (0.034)
## Item.38   0.643 (0.028)
## Item.39   0.667 (0.025)
## Item.40   0.713 (0.022)
## Item.41   0.437 (0.036)
## Item.42   0.481 (0.054)
## Item.43   0.474 (0.034)
## Item.44   0.481 (0.033)
## Item.45   0.596 (0.028)
## Item.46   0.598 (0.025)
## Item.47   0.612 (0.024)
## Item.48   0.642 (0.022)
## Item.49   0.613 (0.025)
## Item.50   0.587 (0.027)
## Item.51   0.394 (0.042)
## Item.52   0.550 (0.030)
## Item.53   0.512 (0.032)
## Item.54   0.448 (0.036)
## Item.55   0.463 (0.035)
## Item.56   0.495 (0.037)
## Item.57   0.454 (0.035)
## Item.58   0.345 (0.043)
## Item.59   0.340 (0.040)
## Item.60   0.798 (0.025)
## Item.61   0.803 (0.037)
## Item.62   0.641 (0.025)
## Item.63   0.615 (0.028)
## Item.64   0.343 (0.040)
## Item.65   0.586 (0.033)
## Item.66   0.584 (0.034)
## Item.67   0.623 (0.032)
## Item.68   0.643 (0.029)
## Item.69   0.344 (0.051)
## Item.70   0.463 (0.034)
```

```
## Item.71   0.688 (0.028)
## Item.72   0.505 (0.032)
## Item.73   0.646 (0.040)
## Item.74   0.585 (0.040)
```

Appendix 11 – Monotonicity, Round 1

```
##          ItemH #ac #vi #vi/#ac maxvi  sum sum/#ac zmax #zsig crit
## Item.1   0.35   3   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.2   0.45   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.3   0.54   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.4   0.47   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.5   0.51   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.6   0.51   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.7   0.57   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.8   0.48   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.9   0.58   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.10  0.62   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.11  0.61   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.12  0.58   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.13  0.53   2   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.14  0.52   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.15  0.50   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.16  0.53   3   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.17  0.45   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.18  0.48   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.19  0.49   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.20  0.59   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.21  0.50   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.22  0.21   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.23  0.51   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.24  0.47   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.25  0.38   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.26  0.49   3   1    0.33  0.09 0.09  0.0287 1.08     0   70
## Item.27  0.40   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.28  0.44   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.29  0.35   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.30  0.41   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.31  0.47   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.32  0.43   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.33  0.40   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.34  0.41   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.35  0.42   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.36  0.52   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.37  0.50   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.38  0.64   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.39  0.67   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.40  0.71   3   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.41  0.44   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.42  0.48   1   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.43  0.47   3   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.44  0.48   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.45  0.60   3   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.46  0.60   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.47  0.61   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.48  0.64   1   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.49  0.61   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.50  0.59   6   0    0.00  0.00 0.00  0.0000 0.00     0    0
```

```
## Item.51  0.39   6   0     0.00   0.00 0.00  0.0000 0.00      0    0
## Item.52  0.55   6   0     0.00   0.00 0.00  0.0000 0.00      0    0
## Item.53  0.51   6   0     0.00   0.00 0.00  0.0000 0.00      0    0
## Item.54  0.45   6   0     0.00   0.00 0.00  0.0000 0.00      0    0
## Item.55  0.46   6   0     0.00   0.00 0.00  0.0000 0.00      0    0
## Item.56  0.50   6   0     0.00   0.00 0.00  0.0000 0.00      0    0
## Item.57  0.45   6   0     0.00   0.00 0.00  0.0000 0.00      0    0
## Item.58  0.34   6   0     0.00   0.00 0.00  0.0000 0.00      0    0
## Item.59  0.34   6   0     0.00   0.00 0.00  0.0000 0.00      0    0
## Item.60  0.80   1   0     0.00   0.00 0.00  0.0000 0.00      0    0
## Item.61  0.80   2   0     0.00   0.00 0.00  0.0000 0.00      0    0
## Item.62  0.64   3   0     0.00   0.00 0.00  0.0000 0.00      0    0
## Item.63  0.61   3   0     0.00   0.00 0.00  0.0000 0.00      0    0
## Item.64  0.34   6   0     0.00   0.00 0.00  0.0000 0.00      0    0
## Item.65  0.59   6   0     0.00   0.00 0.00  0.0000 0.00      0    0
## Item.66  0.58   6   0     0.00   0.00 0.00  0.0000 0.00      0    0
## Item.67  0.62   6   0     0.00   0.00 0.00  0.0000 0.00      0    0
## Item.68  0.64   3   0     0.00   0.00 0.00  0.0000 0.00      0    0
## Item.69  0.34   6   0     0.00   0.00 0.00  0.0000 0.00      0    0
## Item.70  0.46   6   0     0.00   0.00 0.00  0.0000 0.00      0    0
## Item.71  0.69   3   0     0.00   0.00 0.00  0.0000 0.00      0    0
## Item.72  0.51   6   0     0.00   0.00 0.00  0.0000 0.00      0    0
## Item.73  0.65   0   0      NaN   0.00 0.00     NaN 0.00      0    0
## Item.74  0.58   6   0     0.00   0.00 0.00  0.0000 0.00      0    0
```

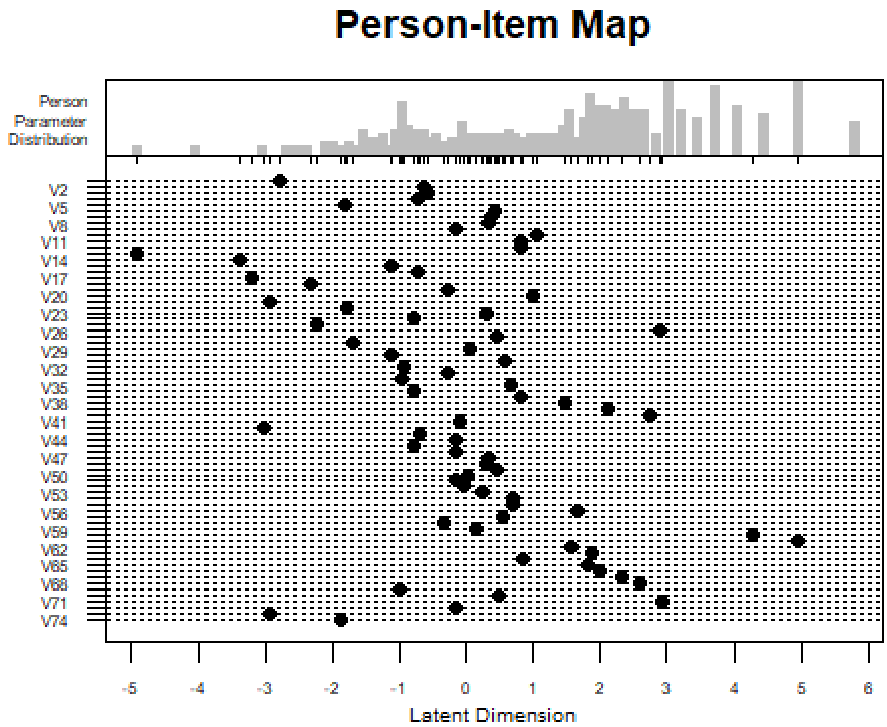
Appendix 12 – Invariant Item Ordering, Round 1

```
##          ItemH #ac #vi #vi/#ac maxvi  sum sum/#ac zmax #zsig crit
## Item.13  0.53 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.14  0.52 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.17  0.45 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.42  0.48 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.73  0.65 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.21  0.50 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.1   0.35 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.18  0.48 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.25  0.38 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.74  0.58 219   1    0.00  0.22 0.22  0.0010 2.91     1   39
## Item.5   0.51 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.22  0.21 219   1    0.00  0.22 0.22  0.0010 2.91     1   58
## Item.28  0.44 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.30  0.41 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.15  0.50 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.69  0.34 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.34  0.41 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.32  0.42 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.36  0.52 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.45  0.60 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.24  0.47 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.16  0.53 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.4   0.47 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.43  0.47 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.2   0.45 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.3   0.54 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.58  0.34 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.33  0.40 219   1    0.00  0.18 0.18  0.0008 2.51     1   42
## Item.19  0.49 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.72  0.50 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.51  0.39 219   1    0.00  0.18 0.18  0.0008 2.51     1   43
## Item.46  0.60 219   2    0.01  0.25 0.44  0.0020 3.45     2   53
## Item.44  0.48 219   0    0.00  0.00 0.00  0.0000 0.00     0    0
```

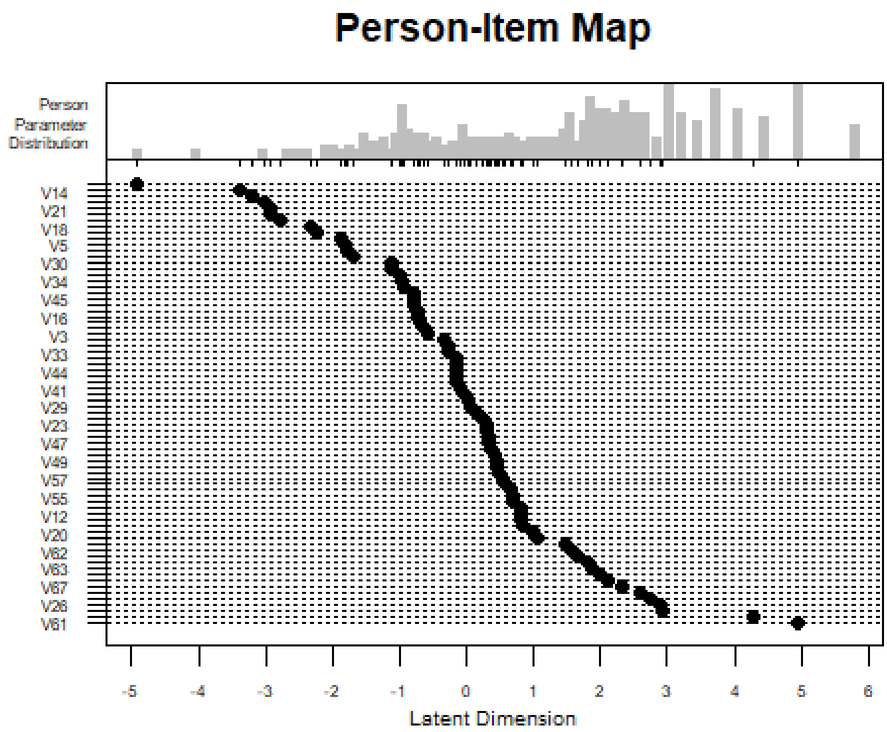
```
## Item.9   0.58 219  2    0.01  0.25 0.44  0.0020 3.46    2   54
## Item.41  0.44 219  0    0.00  0.00 0.00  0.0000 0.00    0    0
## Item.52  0.55 219  2    0.01  0.26 0.47  0.0021 3.69    2   58
## Item.50  0.59 219  4    0.02  0.32 1.01  0.0046 4.78    4   81
## Item.29  0.35 219  4    0.02  0.32 1.08  0.0049 4.78    4   94
## Item.59  0.34 219  4    0.02  0.27 0.86  0.0039 4.09    4   83
## Item.53  0.51 219  0    0.00  0.00 0.00  0.0000 0.00    0    0
## Item.23  0.51 219  1    0.00  0.18 0.18  0.0008 2.68    1   37
## Item.48  0.64 219  7    0.03  0.31 1.63  0.0074 5.74    7   98
## Item.47  0.61 219  3    0.01  0.22 0.60  0.0027 3.49    3   56
## Item.8   0.48 219  1    0.00  0.18 0.18  0.0008 2.31    1   37
## Item.7   0.57 219  1    0.00  0.20 0.20  0.0009 3.10    1   39
## Item.6   0.51 219  2    0.01  0.20 0.39  0.0018 4.13    2   55
## Item.49  0.61 219  4    0.02  0.28 0.95  0.0044 4.94    4   77
## Item.27  0.40 219  4    0.02  0.27 0.89  0.0041 5.20    4   87
## Item.70  0.46 219  0    0.00  0.00 0.00  0.0000 0.00    0    0
## Item.57  0.45 219  0    0.00  0.00 0.00  0.0000 0.00    0    0
## Item.31  0.47 219  1    0.00  0.21 0.21  0.0009 4.32    1   50
## Item.35  0.42 219  2    0.01  0.26 0.49  0.0022 5.02    2   71
## Item.55  0.46 219  1    0.00  0.19 0.19  0.0009 4.13    1   48
## Item.54  0.45 219  1    0.00  0.20 0.20  0.0009 4.31    1   51
## Item.37  0.50 219  0    0.00  0.00 0.00  0.0000 0.00    0    0
## Item.12  0.58 219  1    0.00  0.27 0.27  0.0012 4.58    1   53
## Item.11  0.61 219  1    0.00  0.28 0.28  0.0013 4.93    1   55
## Item.64  0.34 219  9    0.04  0.31 2.18  0.0100 5.74    9  123
## Item.20  0.59 219  1    0.00  0.21 0.21  0.0010 2.69    1   37
## Item.10  0.62 219  0    0.00  0.00 0.00  0.0000 0.00    0    0
## Item.38  0.64 219  0    0.00  0.00 0.00  0.0000 0.00    0    0
## Item.62  0.64 219  0    0.00  0.00 0.00  0.0000 0.00    0    0
## Item.56  0.50 219  0    0.00  0.00 0.00  0.0000 0.00    0    0
## Item.65  0.59 219  0    0.00  0.00 0.00  0.0000 0.00    0    0
## Item.63  0.62 219  0    0.00  0.00 0.00  0.0000 0.00    0    0
## Item.66  0.58 219  0    0.00  0.00 0.00  0.0000 0.00    0    0
## Item.39  0.67 219  0    0.00  0.00 0.00  0.0000 0.00    0    0
## Item.67  0.62 219  0    0.00  0.00 0.00  0.0000 0.00    0    0
## Item.68  0.64 219  0    0.00  0.00 0.00  0.0000 0.00    0    0
```

```
## Item.40  0.71 219   1     0.00   0.29 0.29  0.0013 3.96       1   47
## Item.26  0.49 219   2     0.01   0.29 0.52  0.0024 3.96       2   66
## Item.71  0.69 219   1     0.00   0.22 0.22  0.0010 3.60       1   38
## Item.60  0.80 219   0     0.00   0.00 0.00  0.0000 0.00       0    0
## Item.61  0.80 219   0     0.00   0.00 0.00  0.0000 0.00       0    0
```

Appendix 13 – Person-Item Map, Round 1



Appendix 14 – Person-Item Map Sorted, Round 1



Appendix 15 – Item Difficulty, Standard Error, Round 2

```
##                    value std.err
## Dffclt.Item.1   -4.0651  0.2667
## Dffclt.Item.2   -2.0403  0.1669
## Dffclt.Item.3   -1.9897  0.1657
## Dffclt.Item.4   -2.1152  0.1687
## Dffclt.Item.5   -3.1633  0.2060
## Dffclt.Item.6   -1.0527  0.1502
## Dffclt.Item.7   -1.0924  0.1507
## Dffclt.Item.9   -1.5727  0.1576
## Dffclt.Item.10 -0.4478  0.1446
## Dffclt.Item.11 -0.6873  0.1465
## Dffclt.Item.12 -0.6876  0.1465
## Dffclt.Item.15 -2.4950  0.1793
## Dffclt.Item.16 -2.1163  0.1687
## Dffclt.Item.18 -3.6542  0.2347
## Dffclt.Item.19 -1.7073  0.1600
## Dffclt.Item.20 -0.5206  0.1451
## Dffclt.Item.23 -1.1727  0.1517
## Dffclt.Item.24 -2.1658  0.1699
## Dffclt.Item.26  1.2588  0.1471
## Dffclt.Item.27 -1.0132  0.1497
## Dffclt.Item.30 -2.4961  0.1793
## Dffclt.Item.31 -0.8963  0.1484
## Dffclt.Item.34 -2.3551  0.1750
## Dffclt.Item.36 -2.1917  0.1706
## Dffclt.Item.37 -0.6873  0.1465
## Dffclt.Item.38 -0.0723  0.1427
## Dffclt.Item.39  0.5394  0.1423
## Dffclt.Item.40  1.1102  0.1456
## Dffclt.Item.41 -1.5289  0.1569
## Dffclt.Item.42 -4.2836  0.2872
## Dffclt.Item.43 -2.0903  0.1681
## Dffclt.Item.44 -1.5952  0.1580
## Dffclt.Item.49 -1.0133  0.1497
```

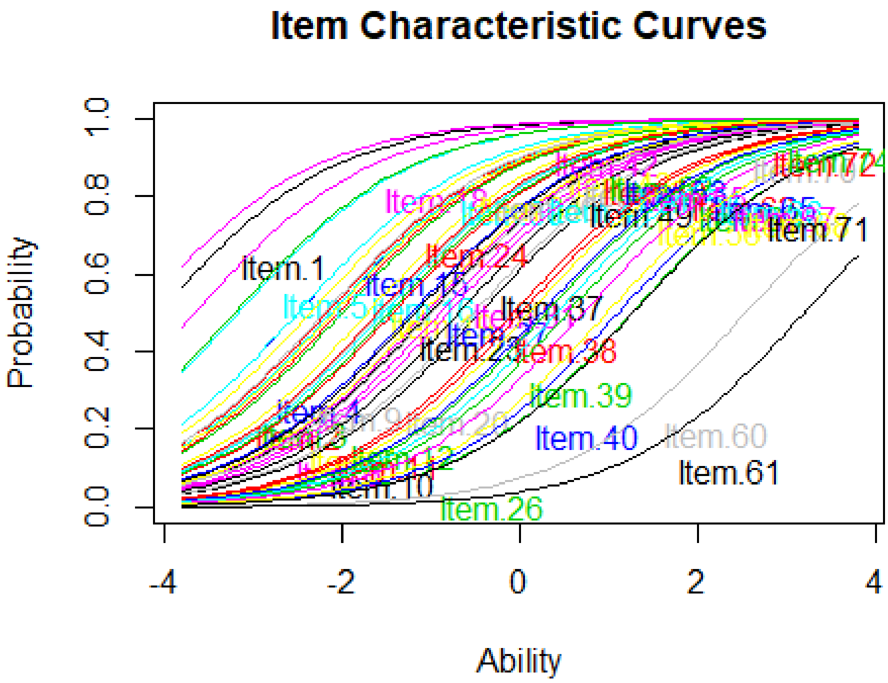
```
## Dffclt.Item.50 -1.4213  0.1551
## Dffclt.Item.52 -1.4638  0.1558
## Dffclt.Item.53 -1.2134  0.1522
## Dffclt.Item.54 -0.8007  0.1475
## Dffclt.Item.55 -0.8007  0.1475
## Dffclt.Item.56  0.1033  0.1422
## Dffclt.Item.60  2.5423  0.1764
## Dffclt.Item.61  3.1988  0.2071
## Dffclt.Item.62  0.0158  0.1424
## Dffclt.Item.63  0.2954  0.1420
## Dffclt.Item.65  0.2428  0.1420
## Dffclt.Item.66  0.4170  0.1420
## Dffclt.Item.67  0.7147  0.1429
## Dffclt.Item.68  0.9825  0.1445
## Dffclt.Item.70 -0.9936  0.1495
## Dffclt.Item.71  1.2777  0.1473
## Dffclt.Item.72 -1.5952  0.1580
## Dffclt.Item.74 -3.2026  0.2080
## Dscrmn          1.0000      NA
```

Appendix 16 – Item Difficulty, Conditional Maximum Likelihood, Round 2

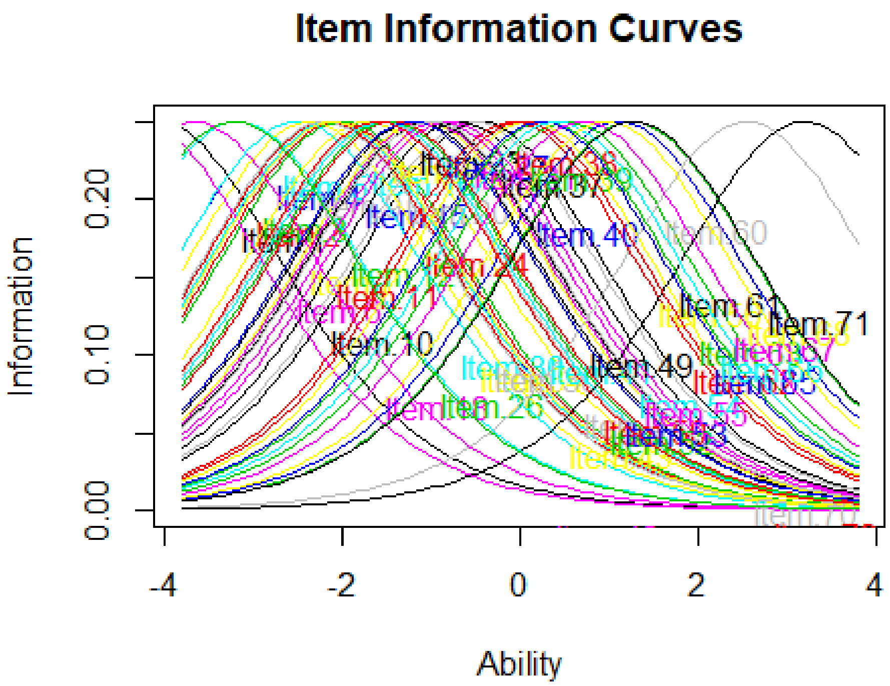
```
## Item Easiness Parameters (beta) with 0.95 CI:
##                Estimate Std. Error lower CI upper CI
## beta Item.1      3.338      0.264    2.819    3.856
## beta Item.2      1.174      0.165    0.851    1.497
## beta Item.3      1.119      0.164    0.798    1.441
## beta Item.4      1.257      0.167    0.931    1.584
## beta Item.5      2.388      0.203    1.991    2.786
## beta Item.6      0.063      0.149   -0.230    0.355
## beta Item.7      0.108      0.150   -0.186    0.401
## beta Item.9      0.653      0.156    0.346    0.959
## beta Item.10    -0.629      0.144   -0.911   -0.348
## beta Item.11    -0.355      0.146   -0.640   -0.070
## beta Item.12    -0.355      0.146   -0.640   -0.070
## beta Item.15     1.673      0.177    1.327    2.019
## beta Item.16     1.257      0.167    0.931    1.584
## beta Item.18     2.906      0.232    2.452    3.361
## beta Item.19     0.804      0.159    0.493    1.114
## beta Item.20    -0.546      0.144   -0.828   -0.263
## beta Item.23     0.199      0.151   -0.096    0.495
## beta Item.24     1.314      0.168    0.985    1.643
## beta Item.26    -2.586      0.149   -2.879   -2.293
## beta Item.27     0.018      0.149   -0.274    0.309
## beta Item.30     1.673      0.177    1.327    2.019
## beta Item.31    -0.116      0.148   -0.405    0.173
## beta Item.34     1.519      0.173    1.181    1.857
## beta Item.36     1.343      0.168    1.012    1.673
## beta Item.37    -0.355      0.146   -0.640   -0.070
## beta Item.38    -1.059      0.142   -1.337   -0.781
## beta Item.39    -1.758      0.142   -2.037   -1.480
## beta Item.40    -2.414      0.147   -2.703   -2.126
## beta Item.41     0.603      0.156    0.298    0.909
## beta Item.42     3.566      0.285    3.007    4.125
## beta Item.43     1.229      0.166    0.904    1.555
## beta Item.44     0.678      0.157    0.370    0.985
## beta Item.49     0.018      0.149   -0.274    0.309
## beta Item.50     0.482      0.154    0.180    0.784
## beta Item.52     0.530      0.155    0.227    0.833
## beta Item.53     0.246      0.151   -0.051    0.542
## beta Item.54    -0.225      0.147   -0.513    0.062
## beta Item.55    -0.225      0.147   -0.513    0.062
## beta Item.56    -1.259      0.141   -1.537   -0.982
## beta Item.60    -4.067      0.185   -4.430   -3.705
## beta Item.61    -4.800      0.218   -5.228   -4.372
## beta Item.62    -1.159      0.142   -1.437   -0.882
## beta Item.63    -1.479      0.141   -1.756   -1.201
## beta Item.65    -1.419      0.141   -1.696   -1.142
## beta Item.66    -1.618      0.142   -1.896   -1.341
## beta Item.67    -1.960      0.143   -2.240   -1.679
## beta Item.68    -2.267      0.146   -2.553   -1.982
## beta Item.70    -0.005      0.149   -0.296    0.286
## beta Item.71    -2.608      0.150   -2.901   -2.315
```

```
## beta Item.72    0.678      0.157    0.370    0.985
## beta Item.74    2.430      0.205    2.029    2.832
```

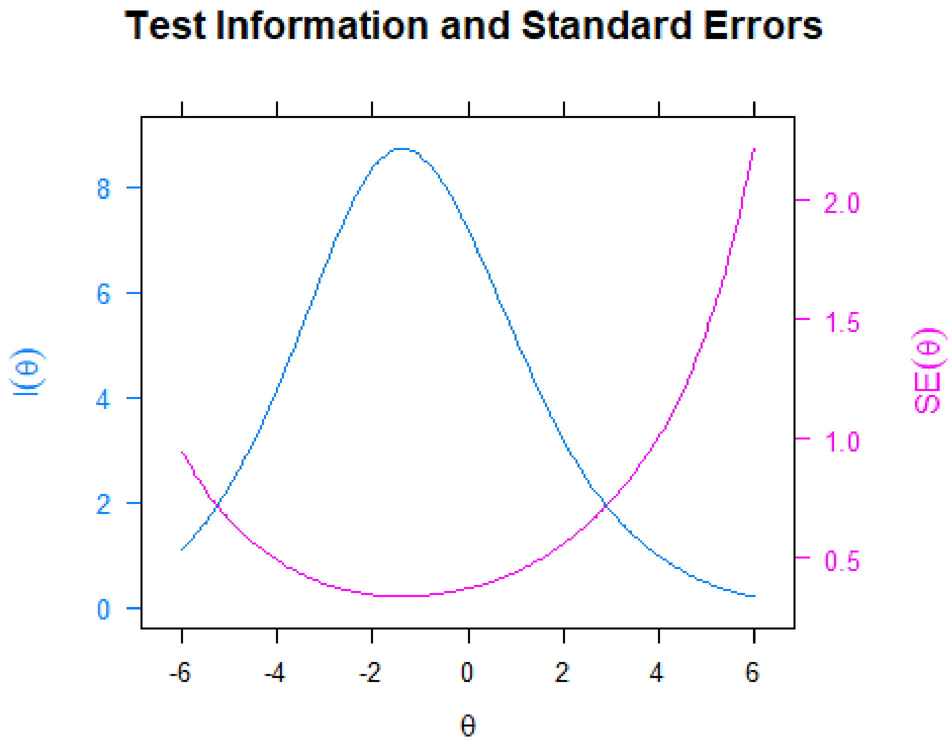
Appendix 17 – Plotted Item Characteristic Curves, Round 2



Appendix 18 – Plotted Item Information Curves, Round 2



Appendix 19 – Plotted Test Information Function, Round 2



Appendix 20 – Unidimenzionality, Round 2

```
##          Item H   se
## Item.1    0.404 (0.083)
## Item.2    0.477 (0.036)
## Item.3    0.592 (0.033)
## Item.4    0.513 (0.041)
## Item.5    0.547 (0.054)
## Item.6    0.552 (0.031)
## Item.7    0.624 (0.027)
## Item.9    0.619 (0.029)
## Item.10   0.653 (0.026)
## Item.11   0.649 (0.025)
## Item.12   0.611 (0.028)
## Item.15   0.550 (0.045)
## Item.16   0.590 (0.032)
## Item.18   0.527 (0.071)
## Item.19   0.525 (0.037)
## Item.20   0.610 (0.029)
## Item.23   0.546 (0.033)
## Item.24   0.529 (0.041)
## Item.26   0.455 (0.042)
## Item.27   0.436 (0.038)
## Item.30   0.408 (0.049)
## Item.31   0.478 (0.037)
## Item.34   0.402 (0.046)
## Item.36   0.532 (0.034)
## Item.37   0.501 (0.036)
## Item.38   0.657 (0.028)
## Item.39   0.672 (0.026)
## Item.40   0.717 (0.024)
## Item.41   0.466 (0.039)
## Item.42   0.573 (0.055)
## Item.43   0.524 (0.035)
## Item.44   0.531 (0.034)
## Item.49   0.641 (0.026)
```

```
## Item.50   0.617 (0.029)
## Item.52   0.595 (0.030)
## Item.53   0.542 (0.033)
## Item.54   0.468 (0.037)
## Item.55   0.493 (0.036)
## Item.56   0.495 (0.038)
## Item.60   0.828 (0.022)
## Item.61   0.823 (0.038)
## Item.62   0.647 (0.026)
## Item.63   0.616 (0.029)
## Item.65   0.600 (0.034)
## Item.66   0.602 (0.034)
## Item.67   0.635 (0.033)
## Item.68   0.648 (0.031)
## Item.70   0.482 (0.036)
## Item.71   0.683 (0.030)
## Item.72   0.541 (0.033)
## Item.74   0.658 (0.043)
```

Appendix 21 – Monotonicity, Round 2

```
##          ItemH #ac #vi #vi/#ac maxvi sum sum/#ac zmax #zsig crit
## Item.1   0.40   3   0       0     0   0       0    0     0    0
## Item.2   0.48   3   0       0     0   0       0    0     0    0
## Item.3   0.59   3   0       0     0   0       0    0     0    0
## Item.4   0.51   6   0       0     0   0       0    0     0    0
## Item.5   0.55   6   0       0     0   0       0    0     0    0
## Item.6   0.55   3   0       0     0   0       0    0     0    0
## Item.7   0.62   6   0       0     0   0       0    0     0    0
## Item.9   0.62   6   0       0     0   0       0    0     0    0
## Item.10  0.65   6   0       0     0   0       0    0     0    0
## Item.11  0.65   6   0       0     0   0       0    0     0    0
## Item.12  0.61   6   0       0     0   0       0    0     0    0
## Item.15  0.55   6   0       0     0   0       0    0     0    0
## Item.16  0.59   3   0       0     0   0       0    0     0    0
## Item.18  0.53   4   0       0     0   0       0    0     0    0
## Item.19  0.53   6   0       0     0   0       0    0     0    0
## Item.20  0.61   6   0       0     0   0       0    0     0    0
## Item.23  0.55   6   0       0     0   0       0    0     0    0
## Item.24  0.53   6   0       0     0   0       0    0     0    0
## Item.26  0.46   3   0       0     0   0       0    0     0    0
## Item.27  0.44   6   0       0     0   0       0    0     0    0
## Item.30  0.41   6   0       0     0   0       0    0     0    0
## Item.31  0.48   6   0       0     0   0       0    0     0    0
## Item.34  0.40   6   0       0     0   0       0    0     0    0
## Item.36  0.53   6   0       0     0   0       0    0     0    0
## Item.37  0.50   6   0       0     0   0       0    0     0    0
## Item.38  0.66   6   0       0     0   0       0    0     0    0
## Item.39  0.67   6   0       0     0   0       0    0     0    0
## Item.40  0.72   3   0       0     0   0       0    0     0    0
## Item.41  0.47   6   0       0     0   0       0    0     0    0
## Item.42  0.57   1   0       0     0   0       0    0     0    0
## Item.43  0.52   3   0       0     0   0       0    0     0    0
## Item.44  0.53   6   0       0     0   0       0    0     0    0
## Item.49  0.64   6   0       0     0   0       0    0     0    0
## Item.50  0.62   6   0       0     0   0       0    0     0    0
## Item.52  0.60   6   0       0     0   0       0    0     0    0
## Item.53  0.54   6   0       0     0   0       0    0     0    0
## Item.54  0.47   6   0       0     0   0       0    0     0    0
## Item.55  0.49   6   0       0     0   0       0    0     0    0
## Item.56  0.49   6   0       0     0   0       0    0     0    0
## Item.60  0.83   1   0       0     0   0       0    0     0    0
## Item.61  0.82   3   0       0     0   0       0    0     0    0
## Item.62  0.65   3   0       0     0   0       0    0     0    0
## Item.63  0.62   3   0       0     0   0       0    0     0    0
## Item.65  0.60   6   0       0     0   0       0    0     0    0
## Item.66  0.60   6   0       0     0   0       0    0     0    0
## Item.67  0.63   6   0       0     0   0       0    0     0    0
## Item.68  0.65   3   0       0     0   0       0    0     0    0
## Item.70  0.48   6   0       0     0   0       0    0     0    0
## Item.71  0.68   3   0       0     0   0       0    0     0    0
```

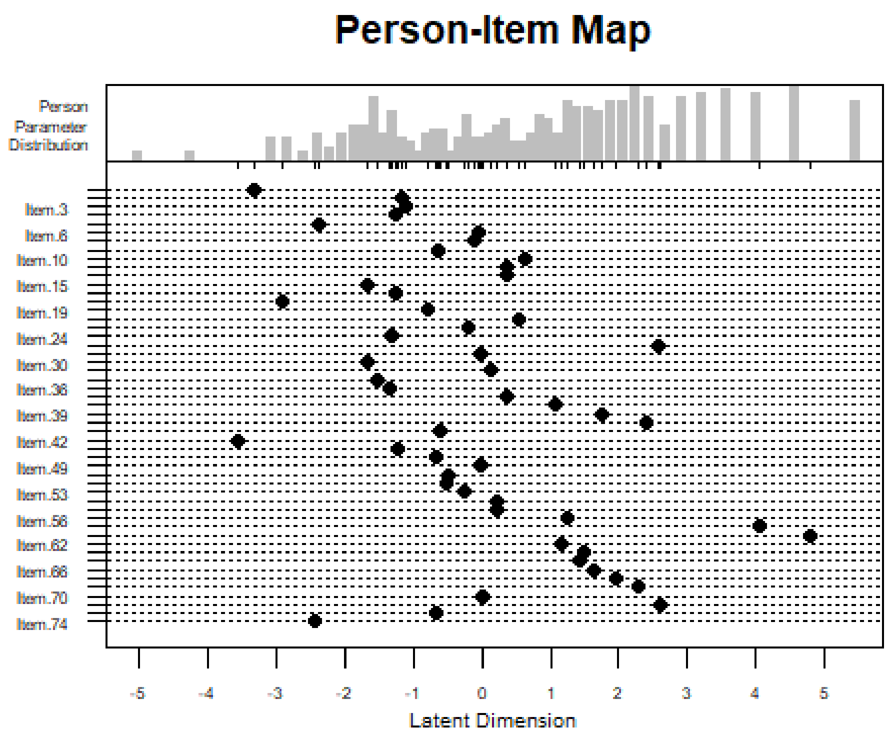
```
## Item.72  0.54   6   0         0      0   0         0     0      0     0
## Item.74  0.66   6   0         0      0   0         0     0      0     0
```

Appendix 22 – Invariant Item Ordering, Round 2

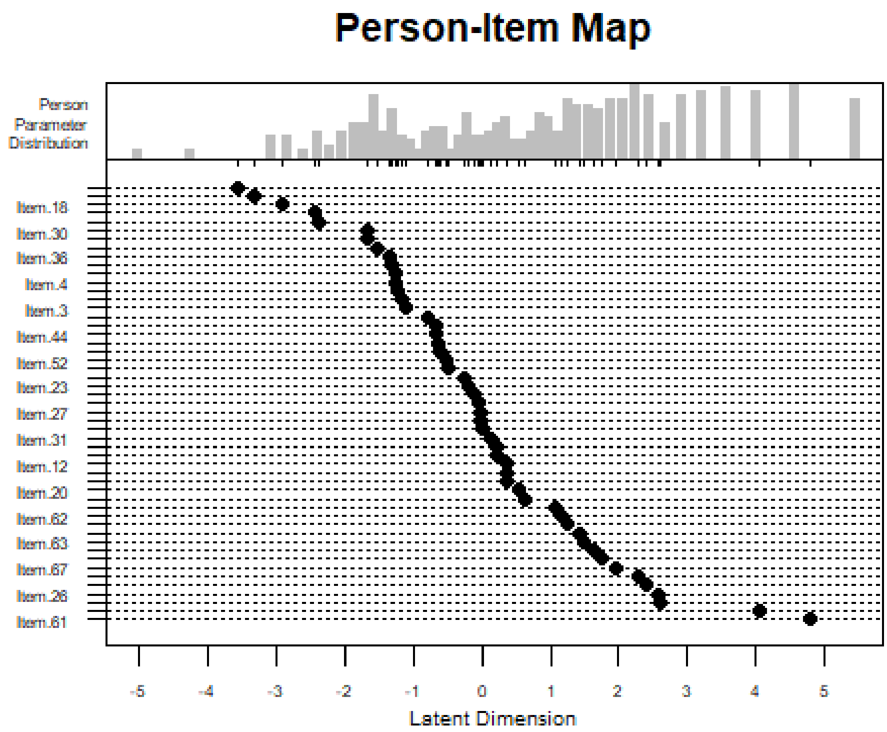
```
##         ItemH #ac #vi #vi/#ac maxvi  sum sum/#ac zmax #zsig crit
## Item.42  0.57 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.1   0.40 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.18  0.53 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.74  0.66 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.5   0.55 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.30  0.41 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.15  0.55 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.34  0.40 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.36  0.53 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.24  0.53 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.16  0.59 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.4   0.51 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.43  0.52 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.2   0.48 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.3   0.59 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.19  0.52 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.72  0.54 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.44  0.53 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.9   0.62 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.41  0.47 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.52  0.60 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.50  0.62 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.53  0.54 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.23  0.55 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.7   0.62 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.6   0.55 150   1    0.01  0.19 0.19  0.0012 2.92     1   38
## Item.49  0.64 150   3    0.02  0.21 0.59  0.0039 3.85     3   57
## Item.27  0.44 150   1    0.01  0.21 0.21  0.0014 3.85     1   51
## Item.70  0.48 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.31  0.48 150   1    0.01  0.19 0.19  0.0013 3.48     1   45
## Item.55  0.49 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.54  0.47 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.37  0.50 150   0    0.00  0.00 0.00  0.0000 0.00     0    0
```

```
## Item.12  0.61 150   0    0.00  0.00 0.00  0.0000 0.00     0     0
## Item.11  0.65 150   0    0.00  0.00 0.00  0.0000 0.00     0     0
## Item.20  0.61 150   0    0.00  0.00 0.00  0.0000 0.00     0     0
## Item.10  0.65 150   0    0.00  0.00 0.00  0.0000 0.00     0     0
## Item.38  0.66 150   1    0.01  0.19 0.19  0.0013 2.87     1    33
## Item.62  0.65 150   0    0.00  0.00 0.00  0.0000 0.00     0     0
## Item.56  0.50 150   1    0.01  0.19 0.19  0.0013 2.87     1    41
## Item.65  0.60 150   0    0.00  0.00 0.00  0.0000 0.00     0     0
## Item.63  0.62 150   0    0.00  0.00 0.00  0.0000 0.00     0     0
## Item.66  0.60 150   0    0.00  0.00 0.00  0.0000 0.00     0     0
## Item.39  0.67 150   0    0.00  0.00 0.00  0.0000 0.00     0     0
## Item.67  0.64 150   0    0.00  0.00 0.00  0.0000 0.00     0     0
## Item.68  0.65 150   0    0.00  0.00 0.00  0.0000 0.00     0     0
## Item.40  0.72 150   2    0.01  0.21 0.40  0.0027 3.69     2    45
## Item.26  0.46 150   3    0.02  0.21 0.61  0.0041 3.69     3    66
## Item.71  0.68 150   1    0.01  0.20 0.20  0.0014 3.32     1    35
## Item.60  0.83 150   0    0.00  0.00 0.00  0.0000 0.00     0     0
## Item.61  0.82 150   0    0.00  0.00 0.00  0.0000 0.00     0     0
```

Appendix 23 – Person-Item Map, Round 2



Appendix 24 – Person-Item Map Sorted, Round 2



Appendix 25 – Item Difficulty, Standard Error, Round 3

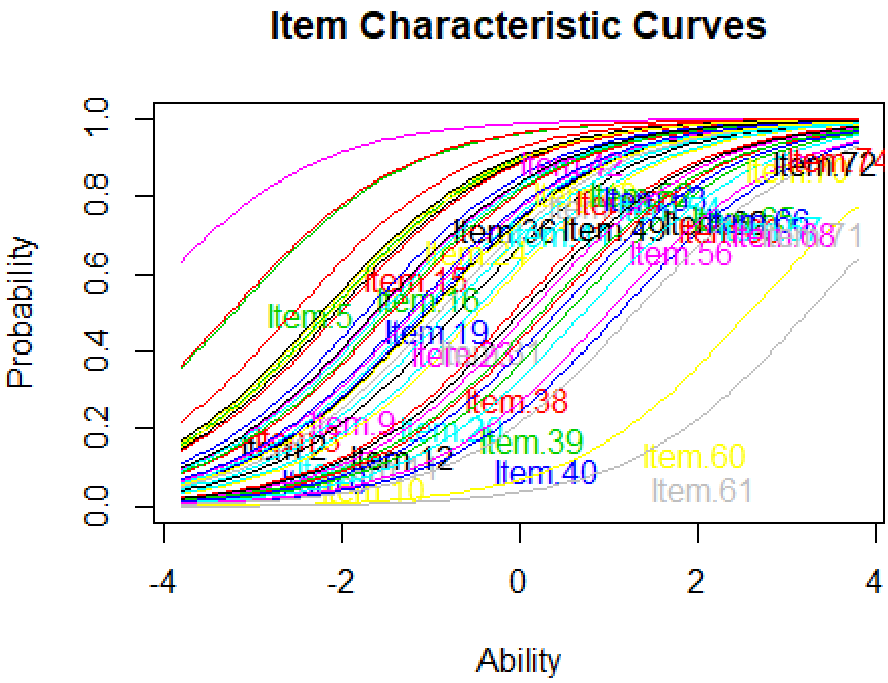
```
##                   value std.err
## Dffclt.Item.2   -2.0715  0.1687
## Dffclt.Item.3   -2.0212  0.1676
## Dffclt.Item.5   -3.2111  0.2079
## Dffclt.Item.6   -1.0697  0.1519
## Dffclt.Item.7   -1.1100  0.1524
## Dffclt.Item.9   -1.5977  0.1594
## Dffclt.Item.10 -0.4561  0.1463
## Dffclt.Item.11 -0.6995  0.1482
## Dffclt.Item.12 -0.6994  0.1482
## Dffclt.Item.15 -2.5342  0.1812
## Dffclt.Item.16 -2.1482  0.1706
## Dffclt.Item.19 -1.7341  0.1618
## Dffclt.Item.20 -0.5301  0.1468
## Dffclt.Item.23 -1.1916  0.1534
## Dffclt.Item.24 -2.2005  0.1718
## Dffclt.Item.31 -0.9115  0.1502
## Dffclt.Item.36 -2.2265  0.1725
## Dffclt.Item.38 -0.0757  0.1443
## Dffclt.Item.39  0.5459  0.1439
## Dffclt.Item.40  1.1260  0.1472
## Dffclt.Item.41 -1.5532  0.1587
## Dffclt.Item.42 -4.3403  0.2885
## Dffclt.Item.43 -2.1225  0.1699
## Dffclt.Item.44 -1.6201  0.1598
## Dffclt.Item.49 -1.0297  0.1515
## Dffclt.Item.50 -1.4441  0.1570
## Dffclt.Item.52 -1.4874  0.1576
## Dffclt.Item.53 -1.2329  0.1540
## Dffclt.Item.54 -0.8144  0.1492
## Dffclt.Item.56  0.1031  0.1438
## Dffclt.Item.60  2.5797  0.1780
## Dffclt.Item.61  3.2443  0.2087
## Dffclt.Item.62  0.0147  0.1440
```

```
## Dffclt.Item.63  0.2978  0.1436
## Dffclt.Item.65  0.2448  0.1436
## Dffclt.Item.66  0.4221  0.1437
## Dffclt.Item.67  0.7247  0.1445
## Dffclt.Item.68  0.9962  0.1461
## Dffclt.Item.70 -1.0099  0.1513
## Dffclt.Item.71  1.2965  0.1489
## Dffclt.Item.72 -1.6201  0.1598
## Dffclt.Item.74 -3.2506  0.2098
## Dscrmn          1.0000      NA
```

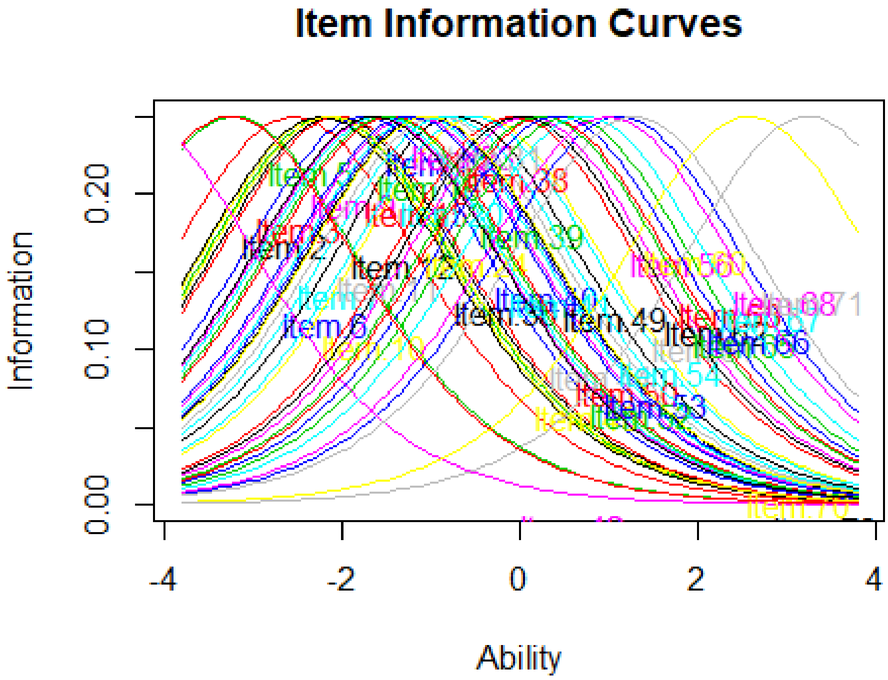
Appendix 26 – Item Difficulty, Conditional Maximum Likelihood, Round 3

```
   ## Item Easiness Parameters (beta) with 0.95 CI:
##                Estimate Std. Error lower CI upper CI
## beta Item.2      1.437      0.170    1.105    1.770
## beta Item.3      1.380      0.169    1.049    1.710
## beta Item.5      2.721      0.209    2.311    3.130
## beta Item.6      0.265      0.153   -0.035    0.565
## beta Item.7      0.312      0.154    0.011    0.613
## beta Item.9      0.887      0.161    0.572    1.202
## beta Item.10    -0.464      0.147   -0.753   -0.176
## beta Item.11    -0.175      0.149   -0.468    0.117
## beta Item.12    -0.175      0.149   -0.468    0.117
## beta Item.15     1.965      0.182    1.609    2.322
## beta Item.16     1.526      0.171    1.190    1.862
## beta Item.19     1.046      0.163    0.727    1.365
## beta Item.20    -0.376      0.148   -0.666   -0.086
## beta Item.23     0.409      0.155    0.106    0.712
## beta Item.24     1.586      0.173    1.247    1.924
## beta Item.31     0.077      0.151   -0.220    0.373
## beta Item.36     1.616      0.173    1.276    1.955
## beta Item.38    -0.917      0.146   -1.203   -0.632
## beta Item.39    -1.659      0.147   -1.947   -1.372
## beta Item.40    -2.363      0.153   -2.664   -2.063
## beta Item.41     0.835      0.160    0.522    1.148
## beta Item.42     3.939      0.289    3.372    4.506
## beta Item.43     1.496      0.171    1.161    1.831
## beta Item.44     0.913      0.161    0.598    1.229
## beta Item.49     0.217      0.153   -0.082    0.516
## beta Item.50     0.707      0.158    0.397    1.016
## beta Item.52     0.758      0.159    0.447    1.069
## beta Item.53     0.458      0.155    0.154    0.762
## beta Item.54    -0.039      0.150   -0.333    0.256
## beta Item.56    -1.129      0.145   -1.414   -0.845
## beta Item.60    -4.199      0.201   -4.593   -3.805
## beta Item.61    -5.075      0.249   -5.564   -4.586
## beta Item.62    -1.024      0.145   -1.309   -0.739
## beta Item.63    -1.362      0.146   -1.647   -1.077
## beta Item.65    -1.299      0.145   -1.584   -1.013
## beta Item.66    -1.510      0.146   -1.796   -1.224
## beta Item.67    -1.874      0.148   -2.165   -1.584
## beta Item.68    -2.205      0.151   -2.501   -1.908
## beta Item.70     0.194      0.152   -0.105    0.492
## beta Item.71    -2.573      0.156   -2.879   -2.267
## beta Item.72     0.913      0.161    0.598    1.229
## beta Item.74     2.765      0.211    2.351    3.178
```

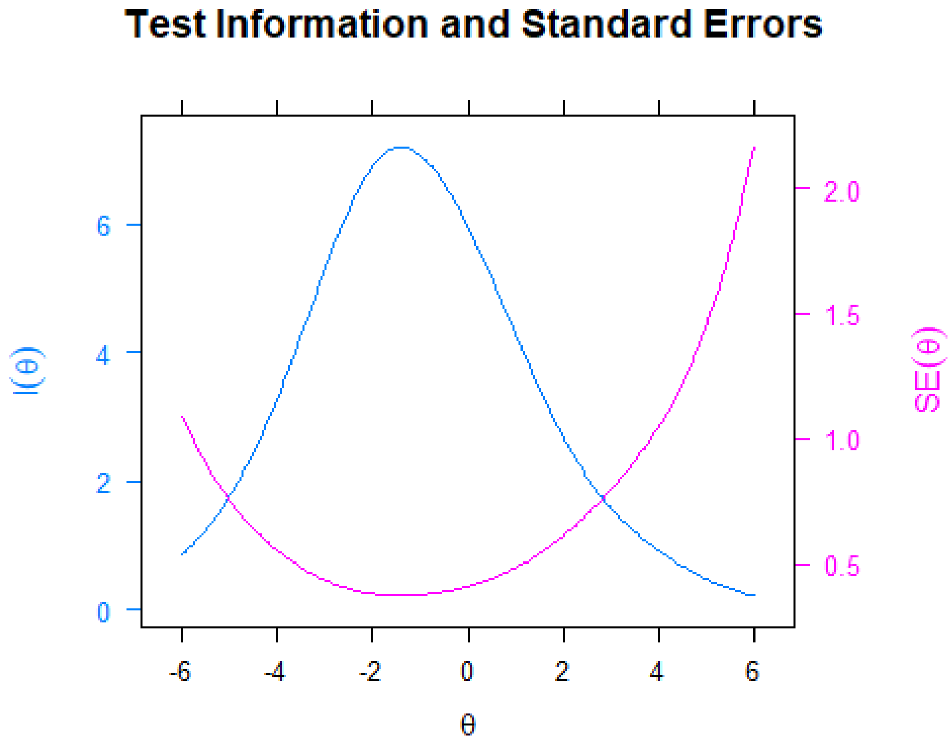
Appendix 27 – Plotted Item Characteristic Curves, Round 3



Appendix 28 – Plotted Item Information Curves, Round 3



Appendix 29 – Plotted Test Information Function, Round 3



Appendix 30 – Unidimensionality, Round 3

```
##          Item H   se
## Item.2    0.490 (0.037)
## Item.3    0.611 (0.034)
## Item.5    0.573 (0.057)
## Item.6    0.576 (0.031)
## Item.7    0.653 (0.026)
## Item.9    0.634 (0.030)
## Item.10   0.682 (0.025)
## Item.11   0.680 (0.024)
## Item.12   0.631 (0.028)
## Item.15   0.596 (0.048)
## Item.16   0.632 (0.033)
## Item.19   0.543 (0.039)
## Item.20   0.626 (0.029)
## Item.23   0.557 (0.035)
## Item.24   0.569 (0.042)
## Item.31   0.481 (0.039)
## Item.36   0.538 (0.036)
## Item.38   0.671 (0.029)
## Item.39   0.680 (0.027)
## Item.40   0.734 (0.025)
## Item.41   0.482 (0.040)
## Item.42   0.647 (0.059)
## Item.43   0.562 (0.036)
## Item.44   0.560 (0.034)
## Item.49   0.661 (0.026)
## Item.50   0.636 (0.029)
## Item.52   0.623 (0.030)
## Item.53   0.563 (0.034)
## Item.54   0.483 (0.038)
## Item.56   0.513 (0.038)
## Item.60   0.862 (0.023)
## Item.61   0.855 (0.036)
## Item.62   0.661 (0.026)
```

```
## Item.63   0.626 (0.030)
## Item.65   0.620 (0.034)
## Item.66   0.619 (0.035)
## Item.67   0.652 (0.033)
## Item.68   0.666 (0.033)
## Item.70   0.495 (0.037)
## Item.71   0.706 (0.030)
## Item.72   0.550 (0.035)
## Item.74   0.723 (0.046)
```

Appendix 31 – Monotonicity, Round 3

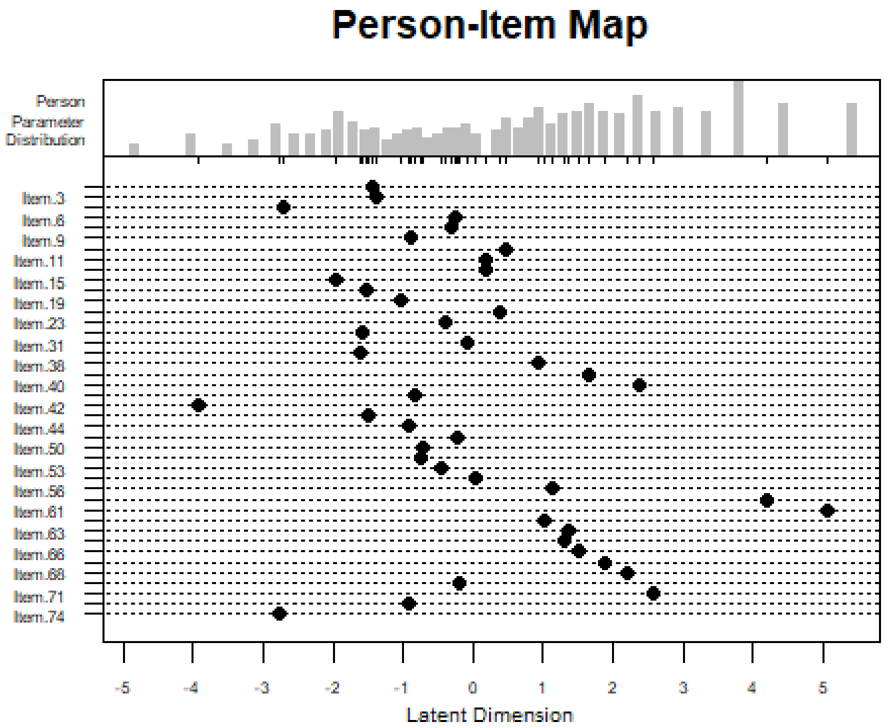
```
##          ItemH #ac #vi #vi/#ac maxvi sum sum/#ac zmax #zsig crit
## Item.2   0.49   3   0       0     0   0       0    0     0    0
## Item.3   0.61   3   0       0     0   0       0    0     0    0
## Item.5   0.57   4   0       0     0   0       0    0     0    0
## Item.6   0.58   3   0       0     0   0       0    0     0    0
## Item.7   0.65   6   0       0     0   0       0    0     0    0
## Item.9   0.63   6   0       0     0   0       0    0     0    0
## Item.10  0.68   6   0       0     0   0       0    0     0    0
## Item.11  0.68   6   0       0     0   0       0    0     0    0
## Item.12  0.63   6   0       0     0   0       0    0     0    0
## Item.15  0.60   6   0       0     0   0       0    0     0    0
## Item.16  0.63   3   0       0     0   0       0    0     0    0
## Item.19  0.54   6   0       0     0   0       0    0     0    0
## Item.20  0.63   6   0       0     0   0       0    0     0    0
## Item.23  0.56   6   0       0     0   0       0    0     0    0
## Item.24  0.57   6   0       0     0   0       0    0     0    0
## Item.31  0.48   6   0       0     0   0       0    0     0    0
## Item.36  0.54   6   0       0     0   0       0    0     0    0
## Item.38  0.67   6   0       0     0   0       0    0     0    0
## Item.39  0.68   6   0       0     0   0       0    0     0    0
## Item.40  0.73   3   0       0     0   0       0    0     0    0
## Item.41  0.48   6   0       0     0   0       0    0     0    0
## Item.42  0.65   1   0       0     0   0       0    0     0    0
## Item.43  0.56   3   0       0     0   0       0    0     0    0
## Item.44  0.56   6   0       0     0   0       0    0     0    0
## Item.49  0.66   6   0       0     0   0       0    0     0    0
## Item.50  0.64   6   0       0     0   0       0    0     0    0
## Item.52  0.62   6   0       0     0   0       0    0     0    0
## Item.53  0.56   6   0       0     0   0       0    0     0    0
## Item.54  0.48   6   0       0     0   0       0    0     0    0
## Item.56  0.51   6   0       0     0   0       0    0     0    0
## Item.60  0.86   1   0       0     0   0       0    0     0    0
## Item.61  0.85   2   0       0     0   0       0    0     0    0
## Item.62  0.66   3   0       0     0   0       0    0     0    0
## Item.63  0.63   3   0       0     0   0       0    0     0    0
## Item.65  0.62   6   0       0     0   0       0    0     0    0
## Item.66  0.62   6   0       0     0   0       0    0     0    0
## Item.67  0.65   6   0       0     0   0       0    0     0    0
## Item.68  0.67   3   0       0     0   0       0    0     0    0
## Item.70  0.49   6   0       0     0   0       0    0     0    0
## Item.71  0.71   3   0       0     0   0       0    0     0    0
## Item.72  0.55   6   0       0     0   0       0    0     0    0
## Item.74  0.72   6   0       0     0   0       0    0     0    0
```

Appendix 32 – Invariant Item Ordering, Round 3

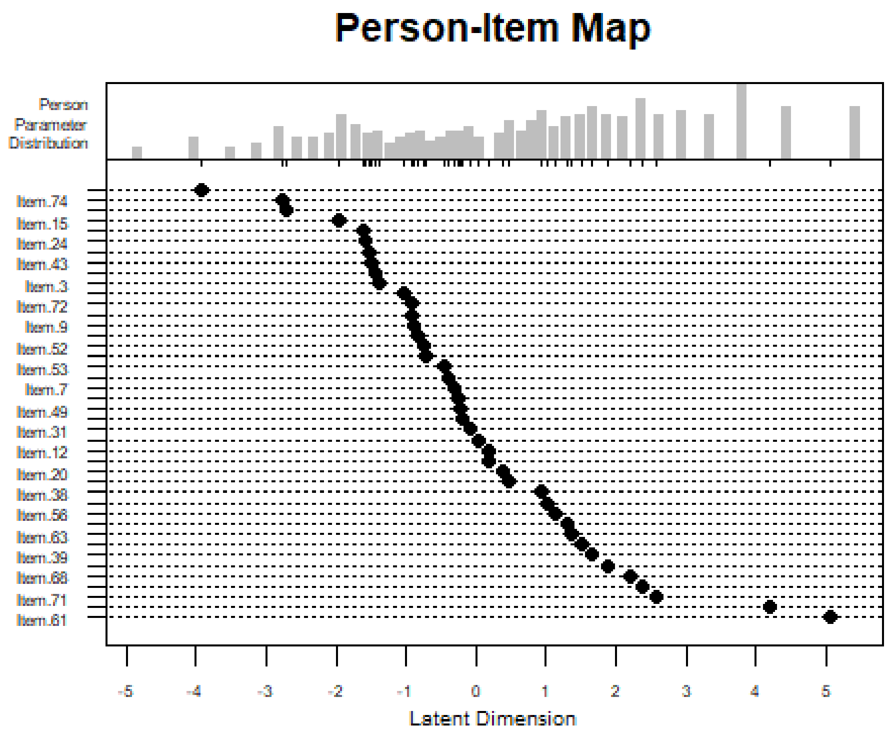
```
##         ItemH #ac #vi #vi/#ac maxvi  sum sum/#ac zmax #zsig crit
## Item.42  0.65 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.74  0.72 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.5   0.57 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.15  0.60 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.36  0.54 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.24  0.57 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.16  0.63 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.43  0.56 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.2   0.49 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.3   0.61 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.19  0.54 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.72  0.55 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.44  0.56 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.9   0.63 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.41  0.48 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.52  0.62 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.50  0.64 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.53  0.56 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.23  0.56 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.7   0.65 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.6   0.58 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.49  0.66 123   2    0.02  0.21 0.41  0.0033 3.83     2   50
## Item.70  0.50 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.31  0.48 123   1    0.01  0.20 0.20  0.0016 3.66     1   47
## Item.54  0.48 123   1    0.01  0.21 0.21  0.0017 3.83     1   49
## Item.12  0.63 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.11  0.68 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.20  0.63 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.10  0.68 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.38  0.67 123   1    0.01  0.18 0.18  0.0015 2.83     1   32
## Item.62  0.66 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.56  0.51 123   1    0.01  0.18 0.18  0.0015 2.83     1   40
## Item.65  0.62 123   0    0.00  0.00 0.00  0.0000 0.00     0    0
```

```
## Item.63  0.63 123   0     0.00   0.00 0.00   0.0000 0.00      0    0
## Item.66  0.62 123   0     0.00   0.00 0.00   0.0000 0.00      0    0
## Item.39  0.68 123   0     0.00   0.00 0.00   0.0000 0.00      0    0
## Item.67  0.65 123   0     0.00   0.00 0.00   0.0000 0.00      0    0
## Item.68  0.67 123   0     0.00   0.00 0.00   0.0000 0.00      0    0
## Item.40  0.73 123   0     0.00   0.00 0.00   0.0000 0.00      0    0
## Item.71  0.71 123   0     0.00   0.00 0.00   0.0000 0.00      0    0
## Item.60  0.86 123   0     0.00   0.00 0.00   0.0000 0.00      0    0
## Item.61  0.86 123   0     0.00   0.00 0.00   0.0000 0.00      0    0
```

Appendix 33 – Person-Item Map, Round 3



Appendix 34 – Person-Item Map Sorted, Round 3



Appendix 35 – Item Difficulty, Standard Error, Round 4

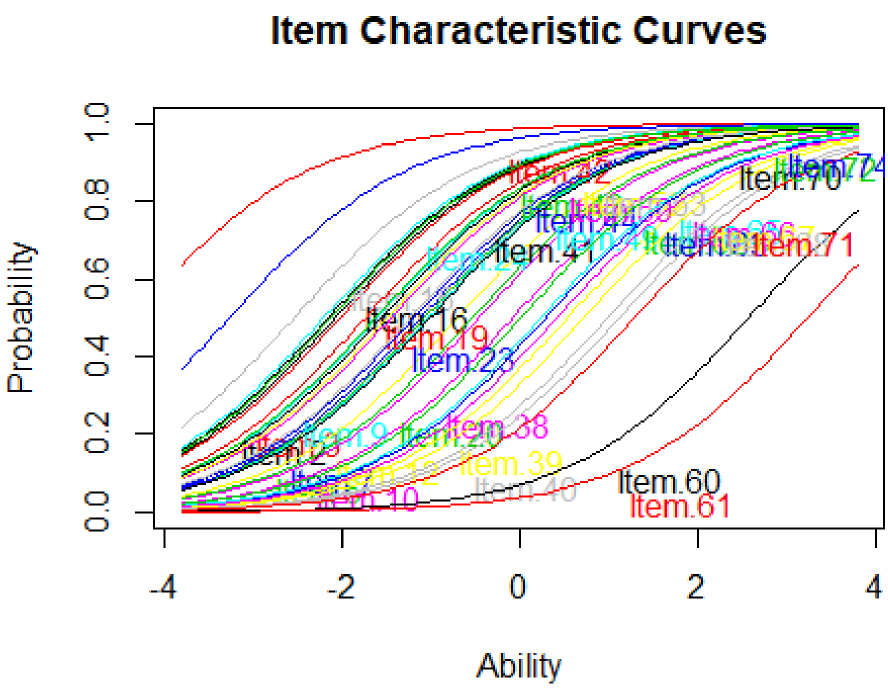
```
## Coefficients:
##                   value std.err
## Dffclt.Item.2   -2.0709  0.1691
## Dffclt.Item.3   -2.0207  0.1680
## Dffclt.Item.6   -1.0697  0.1518
## Dffclt.Item.7   -1.1099  0.1523
## Dffclt.Item.9   -1.5964  0.1595
## Dffclt.Item.10 -0.4585  0.1460
## Dffclt.Item.12 -0.7001  0.1479
## Dffclt.Item.15 -2.5361  0.1819
## Dffclt.Item.16 -2.1477  0.1710
## Dffclt.Item.19 -1.7322  0.1620
## Dffclt.Item.20 -0.5323  0.1465
## Dffclt.Item.23 -1.1907  0.1533
## Dffclt.Item.24 -2.2004  0.1723
## Dffclt.Item.38 -0.0793  0.1441
## Dffclt.Item.39  0.5398  0.1438
## Dffclt.Item.40  1.1192  0.1472
## Dffclt.Item.41 -1.5520  0.1587
## Dffclt.Item.42 -4.3591  0.2900
## Dffclt.Item.43 -2.1222  0.1704
## Dffclt.Item.44 -1.6186  0.1599
## Dffclt.Item.49 -1.0297  0.1513
## Dffclt.Item.50 -1.4425  0.1569
## Dffclt.Item.52 -1.4862  0.1576
## Dffclt.Item.53 -1.2314  0.1538
## Dffclt.Item.60  2.5739  0.1783
## Dffclt.Item.61  3.2391  0.2089
## Dffclt.Item.62  0.0098  0.1438
## Dffclt.Item.63  0.2923  0.1435
## Dffclt.Item.65  0.2394  0.1435
## Dffclt.Item.66  0.4160  0.1435
## Dffclt.Item.67  0.7179  0.1444
## Dffclt.Item.68  0.9895  0.1461
```

```
## Dffclt.Item.70 -1.0096  0.1510
## Dffclt.Item.71  1.2894  0.1490
## Dffclt.Item.72 -1.6185  0.1599
## Dffclt.Item.74 -3.2590  0.2110
## Dscrmn          1.0000      NA
```

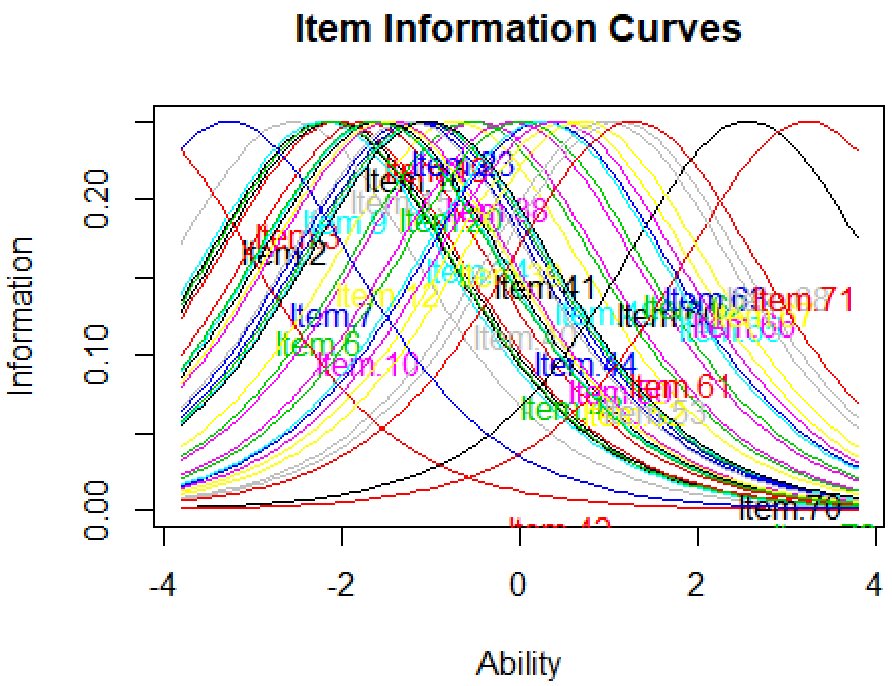
Appendix 36 – Item Difficulty, Conditional Maximum Likelihood, Round 4

```
## Item Easiness Parameters (beta) with 0.95 CI:
##               Estimate Std. Error lower CI upper CI
## beta Item.2      1.572      0.174    1.231    1.912
## beta Item.3      1.511      0.173    1.173    1.849
## beta Item.6      0.355      0.155    0.051    0.659
## beta Item.7      0.404      0.156    0.099    0.709
## beta Item.9      0.998      0.163    0.677    1.318
## beta Item.10    -0.392      0.149   -0.684   -0.100
## beta Item.12    -0.096      0.151   -0.392    0.200
## beta Item.15     2.129      0.188    1.761    2.497
## beta Item.16     1.664      0.176    1.320    2.009
## beta Item.19     1.163      0.166    0.837    1.488
## beta Item.20    -0.302      0.150   -0.595   -0.008
## beta Item.23     0.504      0.157    0.196    0.811
## beta Item.24     1.727      0.177    1.380    2.075
## beta Item.38    -0.856      0.148   -1.146   -0.567
## beta Item.39    -1.621      0.149   -1.914   -1.328
## beta Item.40    -2.354      0.157   -2.662   -2.046
## beta Item.41     0.944      0.163    0.625    1.262
## beta Item.42     4.232      0.301    3.641    4.822
## beta Item.43     1.633      0.175    1.290    1.977
## beta Item.44     1.025      0.164    0.704    1.346
## beta Item.49     0.307      0.155    0.004    0.610
## beta Item.50     0.811      0.161    0.496    1.126
## beta Item.52     0.864      0.161    0.547    1.180
## beta Item.53     0.554      0.157    0.245    0.862
## beta Item.60    -4.273      0.208   -4.680   -3.866
## beta Item.61    -5.191      0.260   -5.700   -4.681
## beta Item.62    -0.965      0.147   -1.254   -0.676
## beta Item.63    -1.314      0.148   -1.604   -1.024
## beta Item.65    -1.248      0.148   -1.538   -0.959
## beta Item.66    -1.467      0.149   -1.758   -1.176
## beta Item.67    -1.844      0.151   -2.140   -1.548
## beta Item.68    -2.188      0.155   -2.492   -1.885
## beta Item.70     0.282      0.154   -0.020    0.585
## beta Item.71    -2.574      0.161   -2.889   -2.259
## beta Item.72     1.025      0.164    0.704    1.346
## beta Item.74     2.983      0.219    2.553    3.413
```

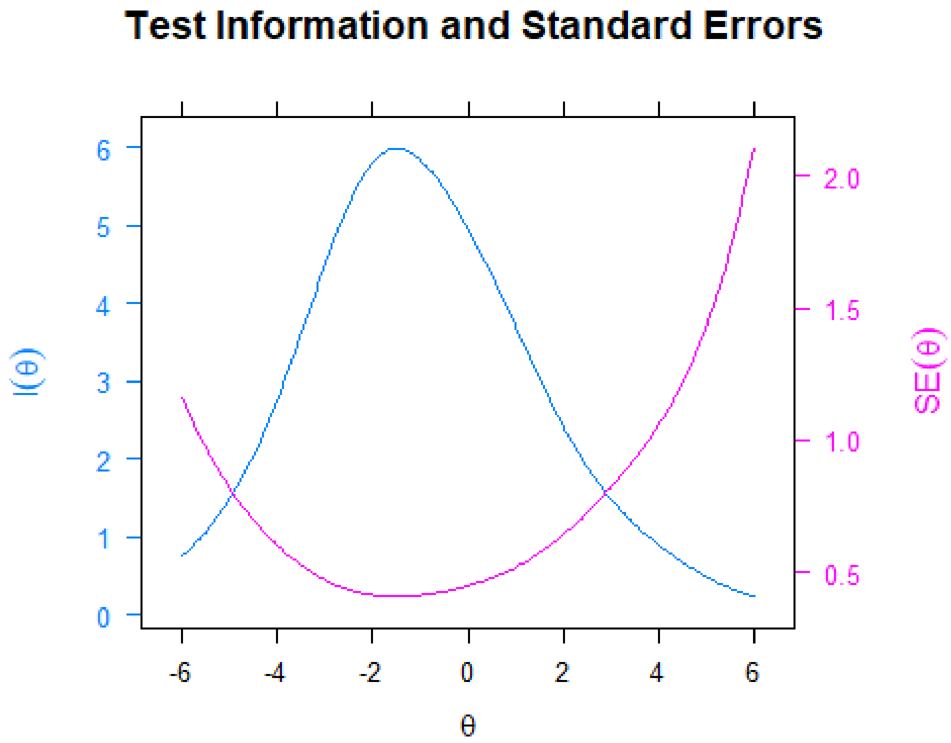
Appendix 37 – Plotted Item Characteristic Curves, Round 4



Appendix 38 – Plotted Item Information Curves, Round 4



Appendix 39 – Plotted Test Information Function, Round 4



Appendix 40 – Unidimensionality, Round 4

```
##            Item H   se
## Item.2    0.474 (0.038)
## Item.3    0.616 (0.035)
## Item.6    0.573 (0.033)
## Item.7    0.661 (0.027)
## Item.9    0.640 (0.030)
## Item.10   0.692 (0.025)
## Item.12   0.645 (0.029)
## Item.15   0.624 (0.050)
## Item.16   0.659 (0.033)
## Item.19   0.557 (0.039)
## Item.20   0.651 (0.029)
## Item.23   0.574 (0.035)
## Item.24   0.602 (0.043)
## Item.38   0.682 (0.030)
## Item.39   0.687 (0.027)
## Item.40   0.741 (0.025)
## Item.41   0.496 (0.040)
## Item.42   0.698 (0.062)
## Item.43   0.591 (0.036)
## Item.44   0.589 (0.034)
## Item.49   0.679 (0.027)
## Item.50   0.646 (0.030)
## Item.52   0.630 (0.031)
## Item.53   0.562 (0.035)
## Item.60   0.870 (0.024)
## Item.61   0.869 (0.036)
## Item.62   0.683 (0.027)
## Item.63   0.645 (0.030)
## Item.65   0.634 (0.035)
## Item.66   0.629 (0.036)
## Item.67   0.664 (0.034)
## Item.68   0.676 (0.033)
## Item.70   0.504 (0.038)
```

```
## Item.71   0.708 (0.031)
## Item.72   0.549 (0.035)
## Item.74   0.775 (0.047)
```

Appendix 41 – Monotonicity, Round 4

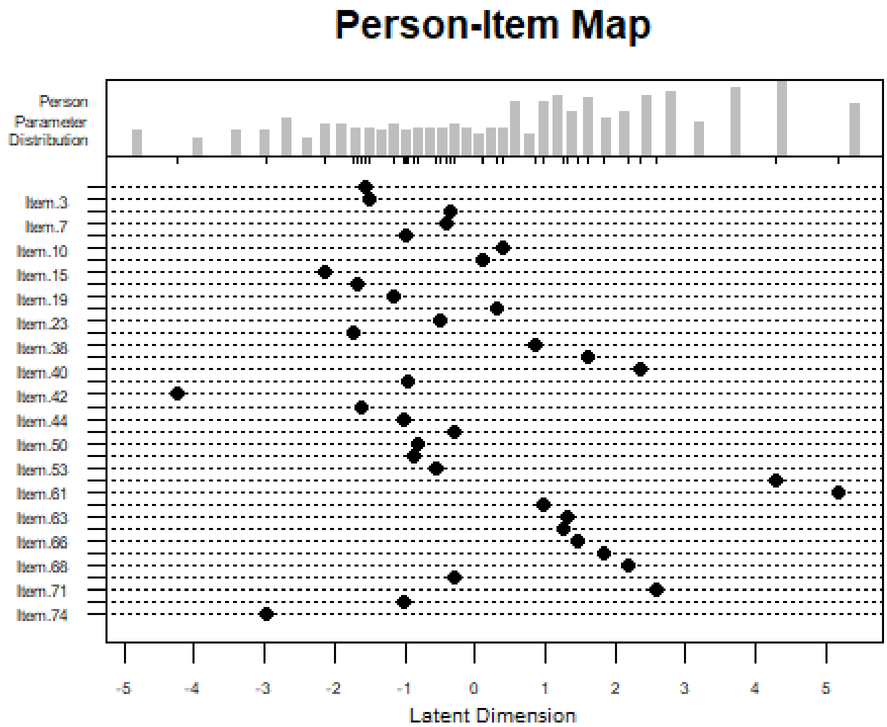
```
##           ItemH #ac #vi #vi/#ac maxvi sum sum/#ac zmax #zsig crit
## Item.2   0.47   3   0       0     0   0       0    0     0    0
## Item.3   0.62   3   0       0     0   0       0    0     0    0
## Item.6   0.57   3   0       0     0   0       0    0     0    0
## Item.7   0.66   6   0       0     0   0       0    0     0    0
## Item.9   0.64   6   0       0     0   0       0    0     0    0
## Item.10  0.69   6   0       0     0   0       0    0     0    0
## Item.12  0.64   6   0       0     0   0       0    0     0    0
## Item.15  0.62   6   0       0     0   0       0    0     0    0
## Item.16  0.66   3   0       0     0   0       0    0     0    0
## Item.19  0.56   6   0       0     0   0       0    0     0    0
## Item.20  0.65   6   0       0     0   0       0    0     0    0
## Item.23  0.57   6   0       0     0   0       0    0     0    0
## Item.24  0.60   6   0       0     0   0       0    0     0    0
## Item.38  0.68   6   0       0     0   0       0    0     0    0
## Item.39  0.69   6   0       0     0   0       0    0     0    0
## Item.40  0.74   3   0       0     0   0       0    0     0    0
## Item.41  0.50   6   0       0     0   0       0    0     0    0
## Item.42  0.70   1   0       0     0   0       0    0     0    0
## Item.43  0.59   3   0       0     0   0       0    0     0    0
## Item.44  0.59   6   0       0     0   0       0    0     0    0
## Item.49  0.68   6   0       0     0   0       0    0     0    0
## Item.50  0.65   6   0       0     0   0       0    0     0    0
## Item.52  0.63   6   0       0     0   0       0    0     0    0
## Item.53  0.56   6   0       0     0   0       0    0     0    0
## Item.60  0.87   1   0       0     0   0       0    0     0    0
## Item.61  0.87   2   0       0     0   0       0    0     0    0
## Item.62  0.68   3   0       0     0   0       0    0     0    0
## Item.63  0.64   3   0       0     0   0       0    0     0    0
## Item.65  0.63   6   0       0     0   0       0    0     0    0
## Item.66  0.63   6   0       0     0   0       0    0     0    0
## Item.67  0.66   6   0       0     0   0       0    0     0    0
## Item.68  0.68   3   0       0     0   0       0    0     0    0
## Item.70  0.50   6   0       0     0   0       0    0     0    0
## Item.71  0.71   3   0       0     0   0       0    0     0    0
## Item.72  0.55   6   0       0     0   0       0    0     0    0
## Item.74  0.77   2   0       0     0   0       0    0     0    0
```

Appendix 42 – Invariant Item Ordering, Round 4

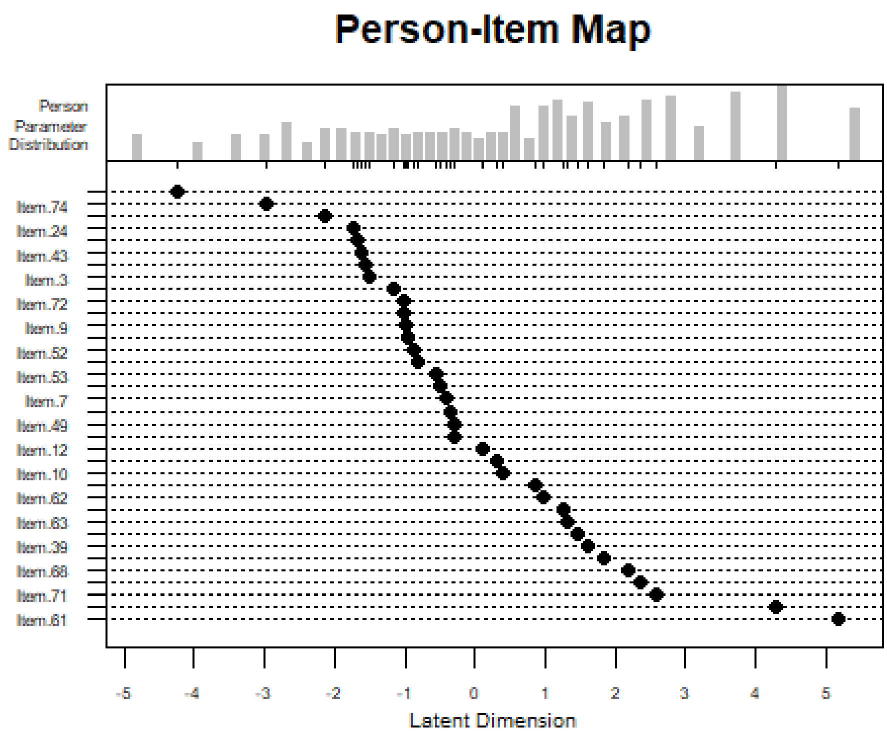
```
##         ItemH #ac #vi #vi/#ac maxvi  sum sum/#ac zmax #zsig crit
## Item.42  0.70 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.74  0.78 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.15  0.62 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.24  0.60 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.16  0.66 105   1    0.01  0.19 0.19  0.0018 2.35     1   31
## Item.43  0.59 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.2   0.47 105   1    0.01  0.19 0.19  0.0018 2.35     1   40
## Item.3   0.62 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.19  0.56 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.72  0.55 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.44  0.59 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.9   0.64 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.41  0.50 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.52  0.63 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.50  0.65 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.53  0.56 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.23  0.57 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.7   0.66 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.6   0.57 105   1    0.01  0.19 0.19  0.0019 3.34     1   41
## Item.49  0.68 105   1    0.01  0.19 0.19  0.0019 3.34     1   36
## Item.70  0.50 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.12  0.64 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.20  0.65 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.10  0.69 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.38  0.68 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.62  0.68 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.65  0.63 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.63  0.64 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.66  0.63 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.39  0.69 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.67  0.66 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.68  0.68 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
## Item.40  0.74 105   0    0.00  0.00 0.00  0.0000 0.00     0    0
```

```
## Item.71  0.71 105    0     0.00   0.00 0.00   0.0000 0.00       0    0
## Item.60  0.87 105    0     0.00   0.00 0.00   0.0000 0.00       0    0
## Item.61  0.87 105    0     0.00   0.00 0.00   0.0000 0.00       0    0
```

Appendix 43 – Person-Item Map, Round 4



Appendix 44 – Person-Item Map Sorted, Round 4



Appendix 45 – Item Difficulty, Standard Error, Round 5

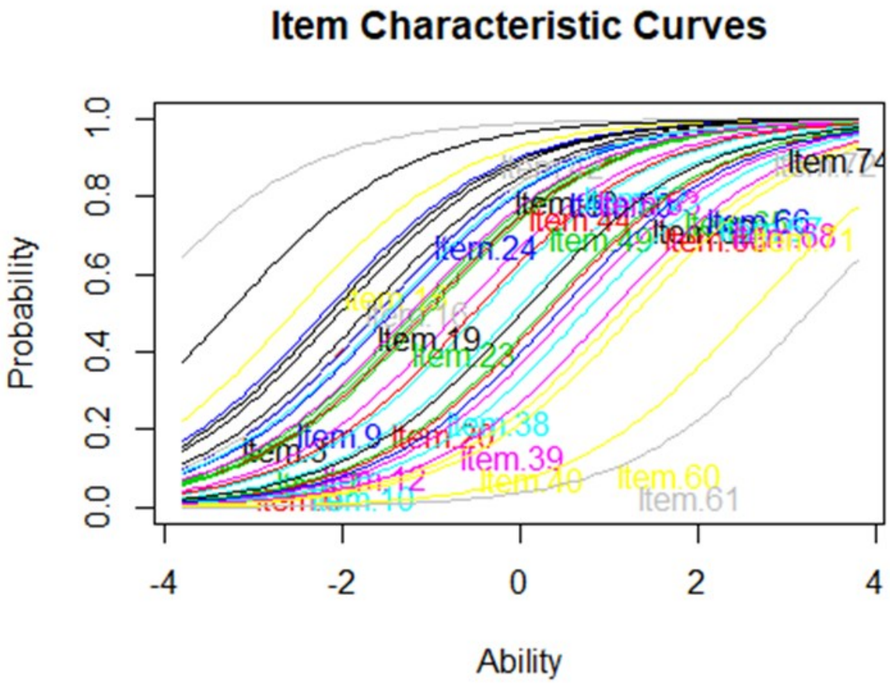
```
## Coefficients:
##                    value std.err
## Dfflct.Item.3   -2.0264  0.1688
## Dfflct.Item.6   -1.0679  0.1521
## Dfflct.Item.7   -1.1083  0.1526
## Dfflct.Item.9   -1.5971  0.1600
## Dfflct.Item.10 -0.4533  0.1463
## Dfflct.Item.12 -0.6971  0.1482
## Dfflct.Item.15 -2.5457  0.1830
## Dfflct.Item.16 -2.1532  0.1718
## Dfflct.Item.19 -1.7329  0.1626
## Dfflct.Item.20 -0.5273  0.1468
## Dfflct.Item.23 -1.1889  0.1537
## Dfflct.Item.24 -2.2066  0.1732
## Dfflct.Item.38 -0.0734  0.1443
## Dfflct.Item.39  0.5476  0.1439
## Dfflct.Item.40  1.1265  0.1473
## Dfflct.Item.42 -4.3896  0.2916
## Dfflct.Item.43 -2.1277  0.1712
## Dfflct.Item.44 -1.6202  0.1605
## Dfflct.Item.49 -1.0273  0.1516
## Dfflct.Item.50 -1.4427  0.1574
## Dfflct.Item.52 -1.4856  0.1581
## Dfflct.Item.53 -1.2300  0.1543
## Dfflct.Item.60  2.5801  0.1782
## Dfflct.Item.61  3.2444  0.2088
## Dfflct.Item.62  0.0165  0.1440
## Dfflct.Item.63  0.2994  0.1436
## Dfflct.Item.65  0.2470  0.1436
## Dfflct.Item.66  0.4230  0.1437
## Dfflct.Item.67  0.7257  0.1446
## Dfflct.Item.68  0.9970  0.1462
## Dfflct.Item.71  1.2972  0.1491
## Dfflct.Item.72 -1.6202  0.1605
```

```
## Dffclt.Item.74 -3.2776  0.2124
## Dscrmn           1.0000      NA
```

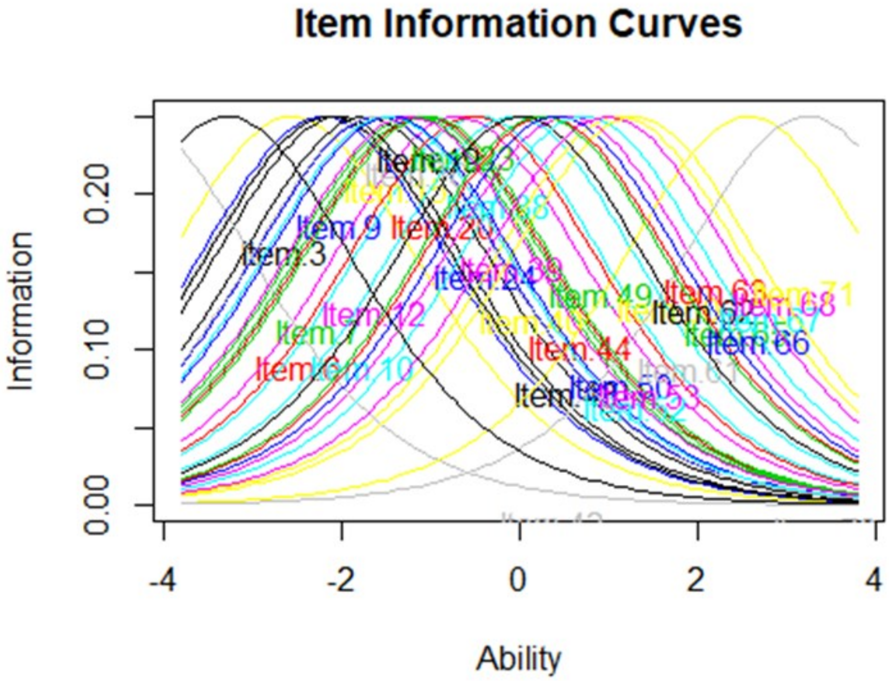
Appendix 46 – Item Difficulty, Conditional Maximum Likelihood, Round 5

```
## Item Easiness Parameters (beta) with 0.95 CI:
##                Estimate Std. Error lower CI upper CI
## beta Item.3      1.644      0.178    1.295    1.993
## beta Item.6      0.434      0.158    0.124    0.744
## beta Item.7      0.485      0.159    0.174    0.796
## beta Item.9      1.103      0.167    0.775    1.431
## beta Item.10    -0.339      0.152   -0.636   -0.042
## beta Item.12    -0.033      0.154   -0.334    0.268
## beta Item.15     2.308      0.196    1.924    2.692
## beta Item.16     1.808      0.182    1.451    2.164
## beta Item.19     1.276      0.170    0.942    1.611
## beta Item.20    -0.246      0.152   -0.544    0.053
## beta Item.23     0.588      0.160    0.275    0.901
## beta Item.24     1.875      0.184    1.515    2.235
## beta Item.38    -0.818      0.150   -1.112   -0.524
## beta Item.39    -1.603      0.151   -1.900   -1.306
## beta Item.40    -2.350      0.159   -2.661   -2.039
## beta Item.42     4.637      0.326    3.998    5.276
## beta Item.43     1.775      0.181    1.420    2.130
## beta Item.44     1.131      0.168    0.802    1.460
## beta Item.49     0.384      0.158    0.075    0.692
## beta Item.50     0.908      0.164    0.586    1.230
## beta Item.52     0.963      0.165    0.639    1.286
## beta Item.53     0.640      0.161    0.326    0.955
## beta Item.60    -4.283      0.209   -4.692   -3.874
## beta Item.61    -5.198      0.260   -5.708   -4.688
## beta Item.62    -0.930      0.150   -1.224   -0.637
## beta Item.63    -1.288      0.150   -1.583   -0.994
## beta Item.65    -1.221      0.150   -1.515   -0.927
## beta Item.66    -1.445      0.151   -1.741   -1.150
## beta Item.67    -1.831      0.153   -2.131   -1.531
## beta Item.68    -2.182      0.157   -2.489   -1.875
## beta Item.71    -2.573      0.162   -2.891   -2.256
## beta Item.72     1.131      0.168    0.802    1.460
## beta Item.74     3.251      0.234    2.793    3.709
```

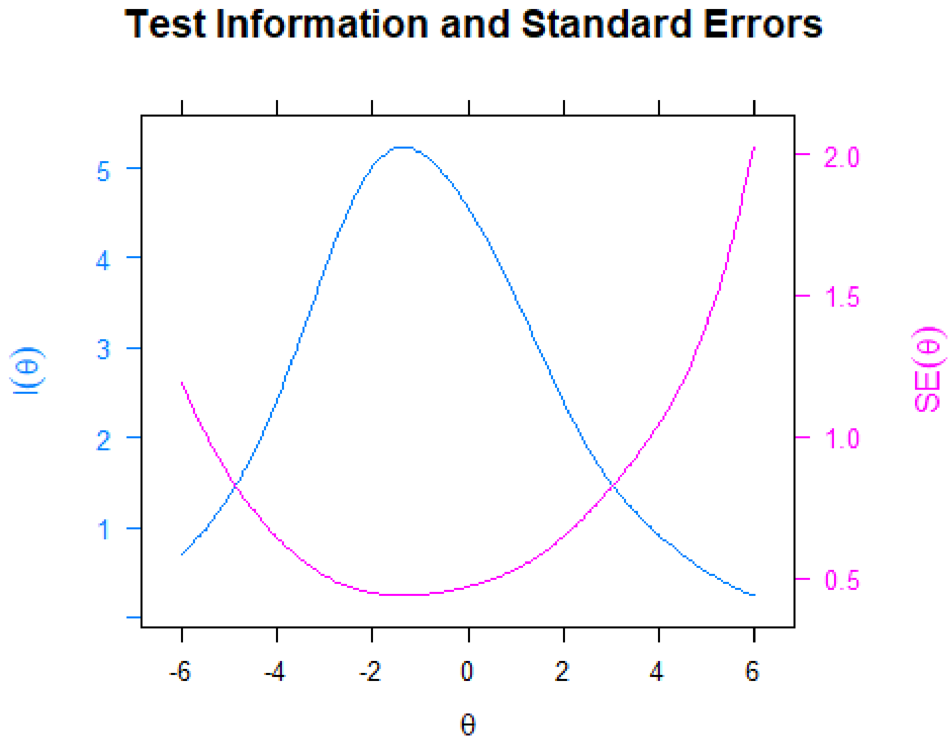
Appendix 47 – Plotted Item Characteristic Curves, Round 5



Appendix 48 – Plotted Item Information Curves, Round 5



Appendix 49 – Plotted Test Information Function, Round 5



Appendix 50 – Unidimensionality, Round 5

```
##          Item H   se
## Item.3    0.629 (0.036)
## Item.6    0.583 (0.035)
## Item.7    0.682 (0.027)
## Item.9    0.665 (0.031)
## Item.10   0.706 (0.025)
## Item.12   0.657 (0.029)
## Item.15   0.659 (0.053)
## Item.16   0.696 (0.033)
## Item.19   0.579 (0.041)
## Item.20   0.664 (0.029)
## Item.23   0.593 (0.035)
## Item.24   0.634 (0.044)
## Item.38   0.687 (0.031)
## Item.39   0.683 (0.028)
## Item.40   0.739 (0.026)
## Item.42   0.712 (0.067)
## Item.43   0.611 (0.037)
## Item.44   0.610 (0.035)
## Item.49   0.696 (0.027)
## Item.50   0.672 (0.030)
## Item.52   0.661 (0.030)
## Item.53   0.586 (0.035)
## Item.60   0.874 (0.023)
## Item.61   0.870 (0.037)
## Item.62   0.687 (0.027)
## Item.63   0.646 (0.030)
## Item.65   0.637 (0.035)
## Item.66   0.632 (0.036)
## Item.67   0.669 (0.033)
## Item.68   0.680 (0.033)
## Item.71   0.699 (0.032)
## Item.72   0.563 (0.036)
## Item.74   0.818 (0.047)
```

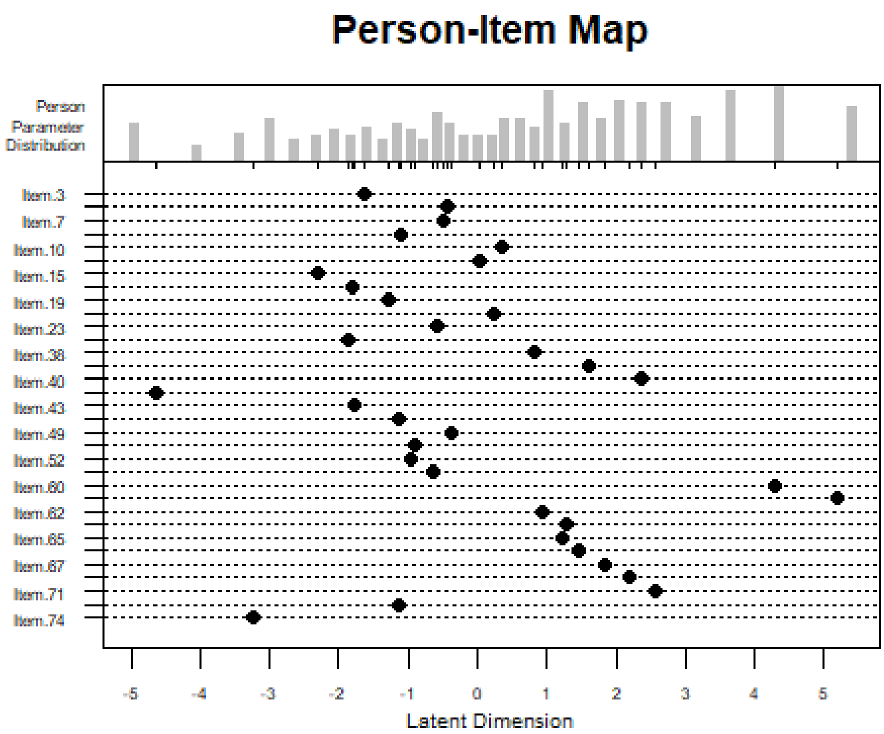
Appendix 51 – Monotonicity, Round 5

```
##          ItemH #ac #vi #vi/#ac maxvi sum sum/#ac zmax #zsig crit
## Item.3    0.63   3   0       0     0   0       0    0     0    0
## Item.6    0.58   3   0       0     0   0       0    0     0    0
## Item.7    0.68   6   0       0     0   0       0    0     0    0
## Item.9    0.66   6   0       0     0   0       0    0     0    0
## Item.10   0.71   6   0       0     0   0       0    0     0    0
## Item.12   0.66   6   0       0     0   0       0    0     0    0
## Item.15   0.66   6   0       0     0   0       0    0     0    0
## Item.16   0.70   3   0       0     0   0       0    0     0    0
## Item.19   0.58   6   0       0     0   0       0    0     0    0
## Item.20   0.66   6   0       0     0   0       0    0     0    0
## Item.23   0.59   6   0       0     0   0       0    0     0    0
## Item.24   0.63   6   0       0     0   0       0    0     0    0
## Item.38   0.69   6   0       0     0   0       0    0     0    0
## Item.39   0.68   6   0       0     0   0       0    0     0    0
## Item.40   0.74   3   0       0     0   0       0    0     0    0
## Item.42   0.71   1   0       0     0   0       0    0     0    0
## Item.43   0.61   6   0       0     0   0       0    0     0    0
## Item.44   0.61   6   0       0     0   0       0    0     0    0
## Item.49   0.70   6   0       0     0   0       0    0     0    0
## Item.50   0.67   6   0       0     0   0       0    0     0    0
## Item.52   0.66   6   0       0     0   0       0    0     0    0
## Item.53   0.59   6   0       0     0   0       0    0     0    0
## Item.60   0.87   1   0       0     0   0       0    0     0    0
## Item.61   0.87   2   0       0     0   0       0    0     0    0
## Item.62   0.69   3   0       0     0   0       0    0     0    0
## Item.63   0.65   6   0       0     0   0       0    0     0    0
## Item.65   0.64   6   0       0     0   0       0    0     0    0
## Item.66   0.63   6   0       0     0   0       0    0     0    0
## Item.67   0.67   6   0       0     0   0       0    0     0    0
## Item.68   0.68   3   0       0     0   0       0    0     0    0
## Item.71   0.70   3   0       0     0   0       0    0     0    0
## Item.72   0.56   6   0       0     0   0       0    0     0    0
## Item.74   0.82   2   0       0     0   0       0    0     0    0
```

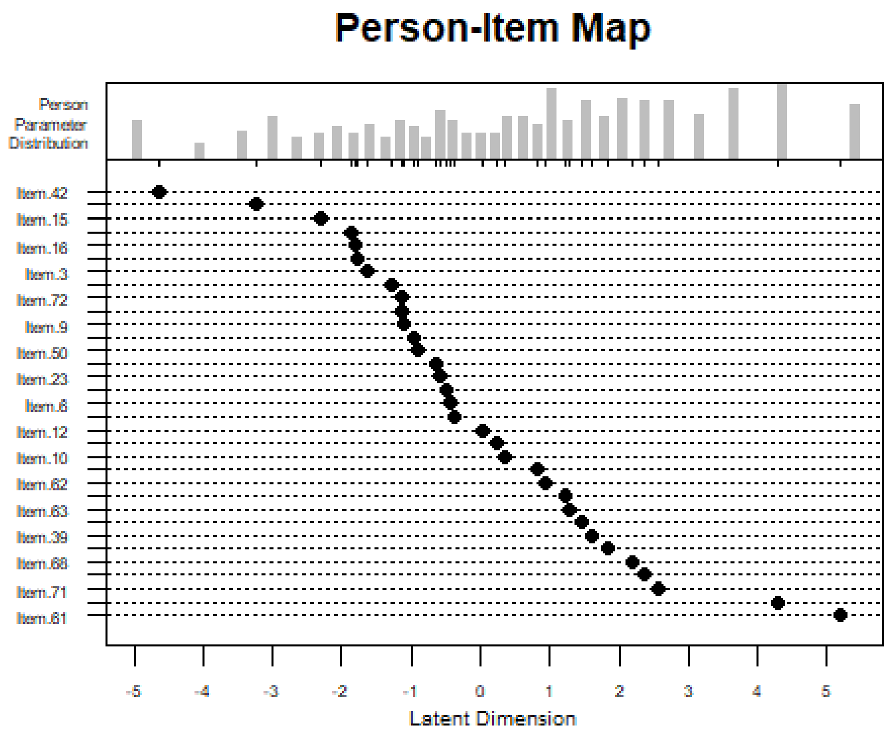
Appendix 52 – Invariant Item Ordering, Round 5

##		ItemH	#ac	#vi	#vi/#ac	maxvi	sum	sum/#ac	zmax	#zsig	crit
##	Item.42	0.71	96	0	0	0	0	0	0	0	0
##	Item.74	0.82	96	0	0	0	0	0	0	0	0
##	Item.15	0.66	96	0	0	0	0	0	0	0	0
##	Item.24	0.63	96	0	0	0	0	0	0	0	0
##	Item.16	0.70	96	0	0	0	0	0	0	0	0
##	Item.43	0.61	96	0	0	0	0	0	0	0	0
##	Item.3	0.63	96	0	0	0	0	0	0	0	0
##	Item.19	0.58	96	0	0	0	0	0	0	0	0
##	Item.72	0.56	96	0	0	0	0	0	0	0	0
##	Item.44	0.61	96	0	0	0	0	0	0	0	0
##	Item.9	0.66	96	0	0	0	0	0	0	0	0
##	Item.52	0.66	96	0	0	0	0	0	0	0	0
##	Item.50	0.67	96	0	0	0	0	0	0	0	0
##	Item.53	0.59	96	0	0	0	0	0	0	0	0
##	Item.23	0.59	96	0	0	0	0	0	0	0	0
##	Item.7	0.68	96	0	0	0	0	0	0	0	0
##	Item.6	0.58	96	0	0	0	0	0	0	0	0
##	Item.49	0.70	96	0	0	0	0	0	0	0	0
##	Item.12	0.66	96	0	0	0	0	0	0	0	0
##	Item.20	0.66	96	0	0	0	0	0	0	0	0
##	Item.10	0.71	96	0	0	0	0	0	0	0	0
##	Item.38	0.69	96	0	0	0	0	0	0	0	0
##	Item.62	0.69	96	0	0	0	0	0	0	0	0
##	Item.65	0.64	96	0	0	0	0	0	0	0	0
##	Item.63	0.65	96	0	0	0	0	0	0	0	0
##	Item.66	0.63	96	0	0	0	0	0	0	0	0
##	Item.39	0.68	96	0	0	0	0	0	0	0	0
##	Item.67	0.67	96	0	0	0	0	0	0	0	0
##	Item.68	0.68	96	0	0	0	0	0	0	0	0
##	Item.40	0.74	96	0	0	0	0	0	0	0	0
##	Item.71	0.70	96	0	0	0	0	0	0	0	0
##	Item.60	0.87	96	0	0	0	0	0	0	0	0
##	Item.61	0.87	96	0	0	0	0	0	0	0	0

Appendix 53 – Person-Item Map, Round 5



Appendix 54 – Person-Item Map Sorted, Round 5



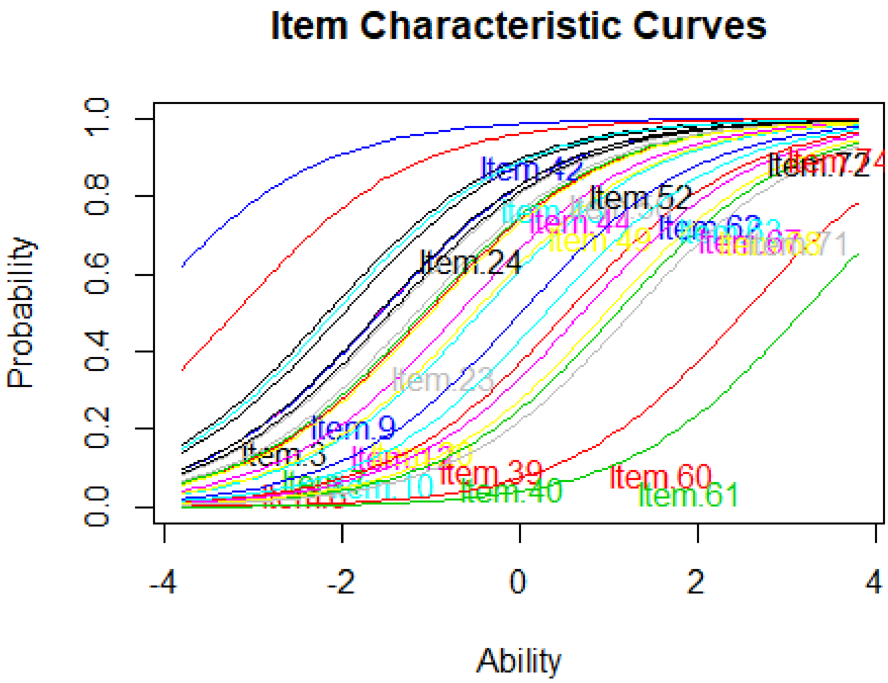
Appendix 55 – Item Difficulty, Standard Error, Round 6

```
## Coefficients:
##                   value std.err
## Dffclt.Item.3   -1.9776  0.1670
## Dffclt.Item.6   -1.0424  0.1505
## Dffclt.Item.7   -1.0817  0.1510
## Dffclt.Item.9   -1.5601  0.1584
## Dffclt.Item.10 -0.4428  0.1446
## Dffclt.Item.12 -0.6803  0.1466
## Dffclt.Item.20 -0.5151  0.1452
## Dffclt.Item.23 -1.1613  0.1521
## Dffclt.Item.24 -2.1549  0.1714
## Dffclt.Item.39  0.5318  0.1422
## Dffclt.Item.40  1.0962  0.1456
## Dffclt.Item.42 -4.2914  0.2896
## Dffclt.Item.43 -2.0778  0.1694
## Dffclt.Item.44 -1.5817  0.1588
## Dffclt.Item.49 -1.0029  0.1500
## Dffclt.Item.50 -1.4091  0.1558
## Dffclt.Item.52 -1.4515  0.1565
## Dffclt.Item.60  2.5169  0.1768
## Dffclt.Item.61  3.1715  0.2077
## Dffclt.Item.62  0.0148  0.1423
## Dffclt.Item.63  0.2908  0.1419
## Dffclt.Item.67  0.7054  0.1428
## Dffclt.Item.68  0.9698  0.1445
## Dffclt.Item.71  1.2619  0.1474
## Dffclt.Item.72 -1.5823  0.1588
## Dffclt.Item.74 -3.2004  0.2103
## Dscrmn          1.0000      NA
```

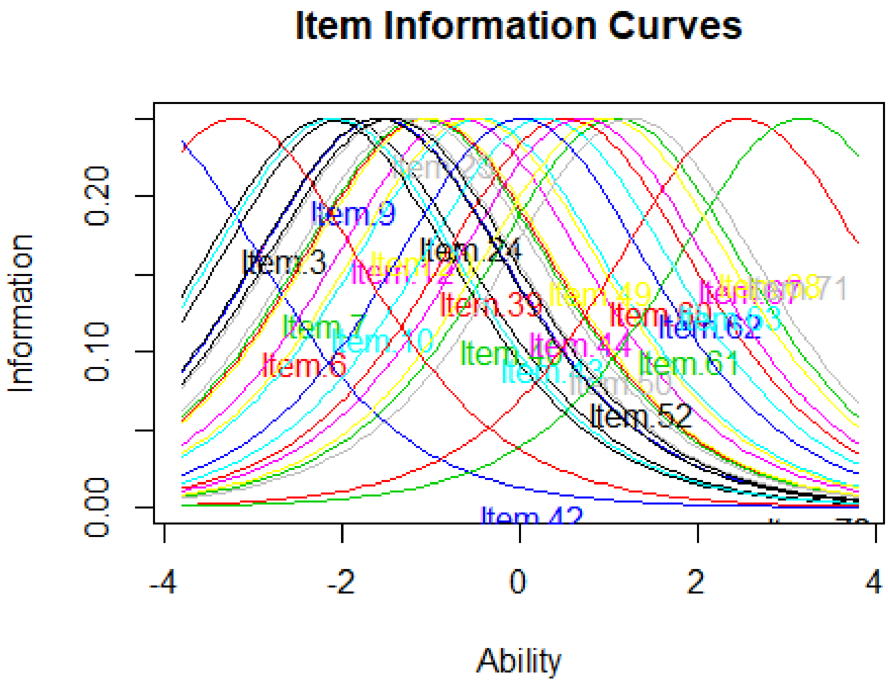
Appendix 56 – Item Difficulty, Conditional Maximum Likelihood, Round 6

```
## Item Easiness Parameters (beta) with 0.95 CI:
##               Estimate Std. Error lower CI upper CI
## beta Item.3      1.783      0.181    1.429    2.137
## beta Item.6      0.530      0.161    0.214    0.846
## beta Item.7      0.583      0.162    0.266    0.900
## beta Item.9      1.225      0.170    0.891    1.560
## beta Item.10    -0.271      0.154   -0.572    0.030
## beta Item.12     0.044      0.156   -0.262    0.351
## beta Item.20    -0.175      0.154   -0.478    0.127
## beta Item.23     0.690      0.163    0.371    1.010
## beta Item.24     2.019      0.186    1.654    2.383
## beta Item.39    -1.544      0.152   -1.841   -1.247
## beta Item.40    -2.280      0.158   -2.590   -1.970
## beta Item.42     4.730      0.321    4.100    5.360
## beta Item.43     1.916      0.183    1.556    2.276
## beta Item.44     1.255      0.171    0.920    1.590
## beta Item.49     0.477      0.161    0.162    0.792
## beta Item.50     1.023      0.167    0.695    1.351
## beta Item.52     1.080      0.168    0.750    1.410
## beta Item.60    -4.180      0.209   -4.589   -3.771
## beta Item.61    -5.079      0.259   -5.588   -4.571
## beta Item.62    -0.873      0.151   -1.168   -0.577
## beta Item.63    -1.232      0.151   -1.527   -0.936
## beta Item.67    -1.770      0.153   -2.069   -1.470
## beta Item.68    -2.115      0.156   -2.421   -1.809
## beta Item.71    -2.499      0.161   -2.815   -2.182
## beta Item.72     1.255      0.171    0.920    1.590
## beta Item.74     3.407      0.236    2.945    3.870
```

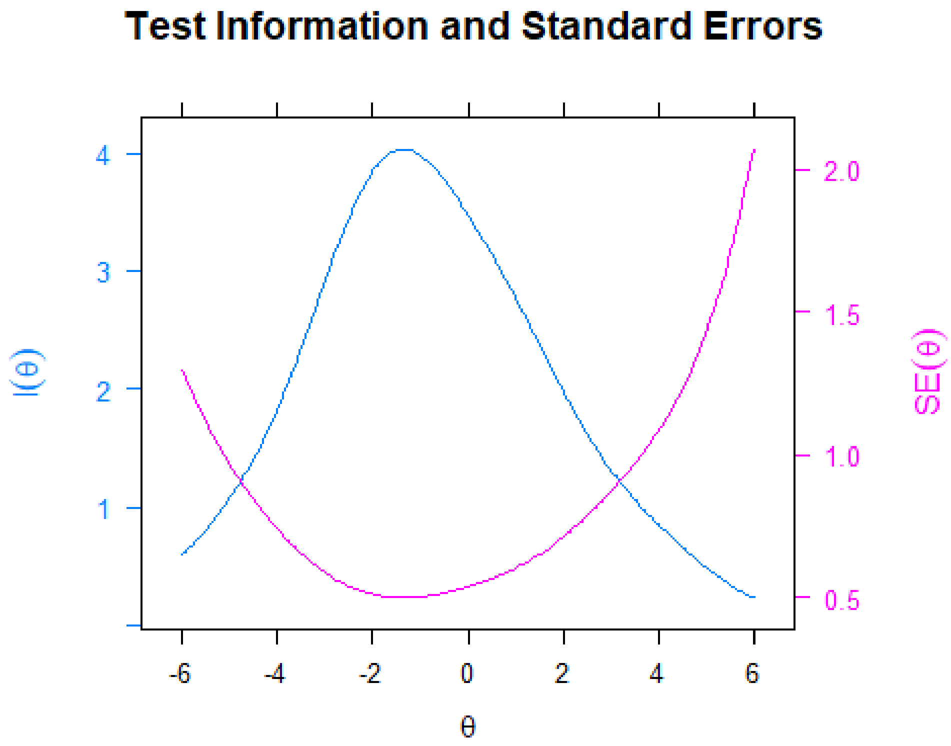
Appendix 57 – Plotted Item Characteristic Curves, Round 6



Appendix 58 – Plotted Item Information Curves, Round 6



Appendix 59 – Plotted Test Information Function, Round 6



Appendix 60 – Unidimensionality, Round 6

```
##          Item H   se
## Item.3    0.644 (0.038)
## Item.6    0.587 (0.035)
## Item.7    0.685 (0.028)
## Item.9    0.679 (0.032)
## Item.10   0.710 (0.027)
## Item.12   0.666 (0.030)
## Item.20   0.675 (0.030)
## Item.23   0.595 (0.036)
## Item.24   0.641 (0.046)
## Item.39   0.687 (0.029)
## Item.40   0.730 (0.027)
## Item.42   0.747 (0.066)
## Item.43   0.629 (0.039)
## Item.44   0.618 (0.037)
## Item.49   0.710 (0.027)
## Item.50   0.682 (0.030)
## Item.52   0.647 (0.033)
## Item.60   0.865 (0.024)
## Item.61   0.859 (0.035)
## Item.62   0.712 (0.027)
## Item.63   0.678 (0.030)
## Item.67   0.680 (0.032)
## Item.68   0.695 (0.031)
## Item.71   0.691 (0.033)
## Item.72   0.579 (0.037)
## Item.74   0.818 (0.047)
```

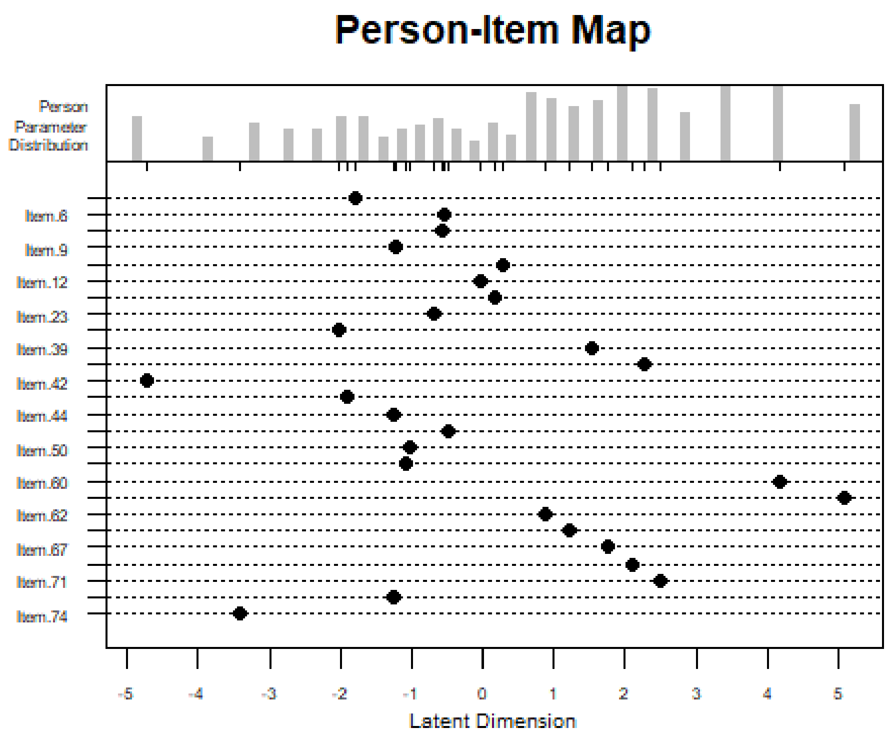
Appendix 61 – Monotonicity, Round 6

```
##          ItemH #ac #vi #vi/#ac maxvi sum sum/#ac zmax #zsig crit
## Item.3   0.64   6   0       0     0   0       0    0     0    0
## Item.6   0.59   6   0       0     0   0       0    0     0    0
## Item.7   0.68   6   0       0     0   0       0    0     0    0
## Item.9   0.68   6   0       0     0   0       0    0     0    0
## Item.10  0.71   6   0       0     0   0       0    0     0    0
## Item.12  0.67   6   0       0     0   0       0    0     0    0
## Item.20  0.67   6   0       0     0   0       0    0     0    0
## Item.23  0.59   6   0       0     0   0       0    0     0    0
## Item.24  0.64   6   0       0     0   0       0    0     0    0
## Item.39  0.69   6   0       0     0   0       0    0     0    0
## Item.40  0.73   3   0       0     0   0       0    0     0    0
## Item.42  0.75   1   0       0     0   0       0    0     0    0
## Item.43  0.63   6   0       0     0   0       0    0     0    0
## Item.44  0.62   6   0       0     0   0       0    0     0    0
## Item.49  0.71   6   0       0     0   0       0    0     0    0
## Item.50  0.68   6   0       0     0   0       0    0     0    0
## Item.52  0.65   6   0       0     0   0       0    0     0    0
## Item.60  0.86   1   0       0     0   0       0    0     0    0
## Item.61  0.86   2   0       0     0   0       0    0     0    0
## Item.62  0.71   3   0       0     0   0       0    0     0    0
## Item.63  0.68   3   0       0     0   0       0    0     0    0
## Item.67  0.68   6   0       0     0   0       0    0     0    0
## Item.68  0.69   3   0       0     0   0       0    0     0    0
## Item.71  0.69   3   0       0     0   0       0    0     0    0
## Item.72  0.58   6   0       0     0   0       0    0     0    0
## Item.74  0.82   2   0       0     0   0       0    0     0    0
```

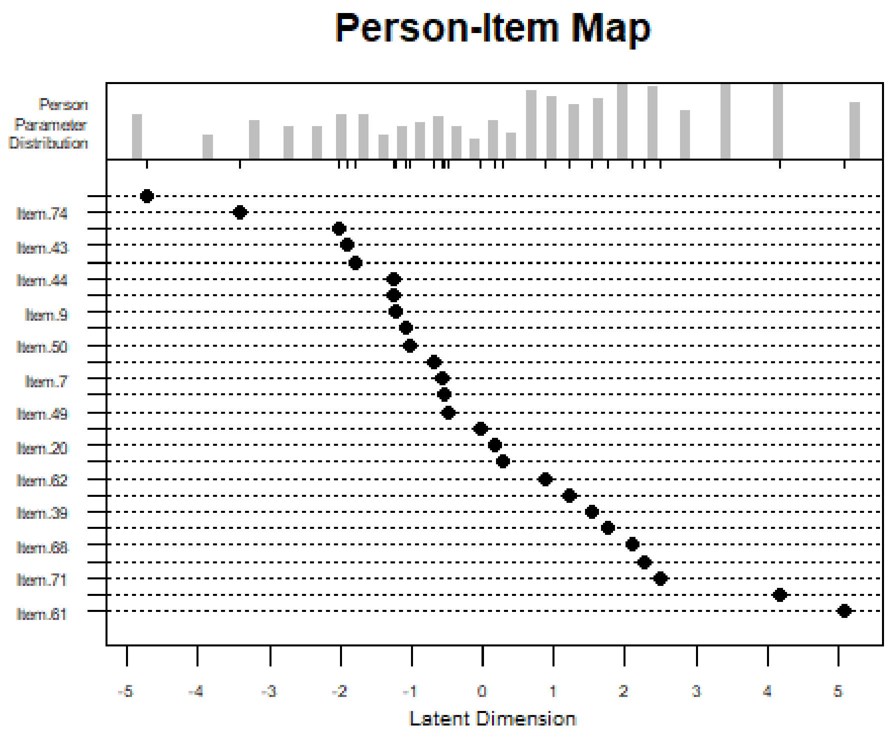
Appendix 62 – Invariant Item Ordering, Round 6

```
##          ItemH #ac #vi #vi/#ac maxvi sum sum/#ac zmax #zsig crit
## Item.42   0.75  75   0       0     0   0       0    0     0    0
## Item.74   0.82  75   0       0     0   0       0    0     0    0
## Item.24   0.64  75   0       0     0   0       0    0     0    0
## Item.43   0.63  75   0       0     0   0       0    0     0    0
## Item.3    0.64  75   0       0     0   0       0    0     0    0
## Item.72   0.58  75   0       0     0   0       0    0     0    0
## Item.44   0.62  75   0       0     0   0       0    0     0    0
## Item.9    0.68  75   0       0     0   0       0    0     0    0
## Item.52   0.65  75   0       0     0   0       0    0     0    0
## Item.50   0.68  75   0       0     0   0       0    0     0    0
## Item.23   0.60  75   0       0     0   0       0    0     0    0
## Item.7    0.68  75   0       0     0   0       0    0     0    0
## Item.6    0.59  75   0       0     0   0       0    0     0    0
## Item.49   0.71  75   0       0     0   0       0    0     0    0
## Item.12   0.67  75   0       0     0   0       0    0     0    0
## Item.20   0.68  75   0       0     0   0       0    0     0    0
## Item.10   0.71  75   0       0     0   0       0    0     0    0
## Item.62   0.71  75   0       0     0   0       0    0     0    0
## Item.63   0.68  75   0       0     0   0       0    0     0    0
## Item.39   0.69  75   0       0     0   0       0    0     0    0
## Item.67   0.68  75   0       0     0   0       0    0     0    0
## Item.68   0.70  75   0       0     0   0       0    0     0    0
## Item.40   0.73  75   0       0     0   0       0    0     0    0
## Item.71   0.69  75   0       0     0   0       0    0     0    0
## Item.60   0.86  75   0       0     0   0       0    0     0    0
## Item.61   0.86  75   0       0     0   0       0    0     0    0
```

Appendix 63 – Person-Item Map, Round 6



Appendix 64 – Person-Item Map Sorted, Round 6



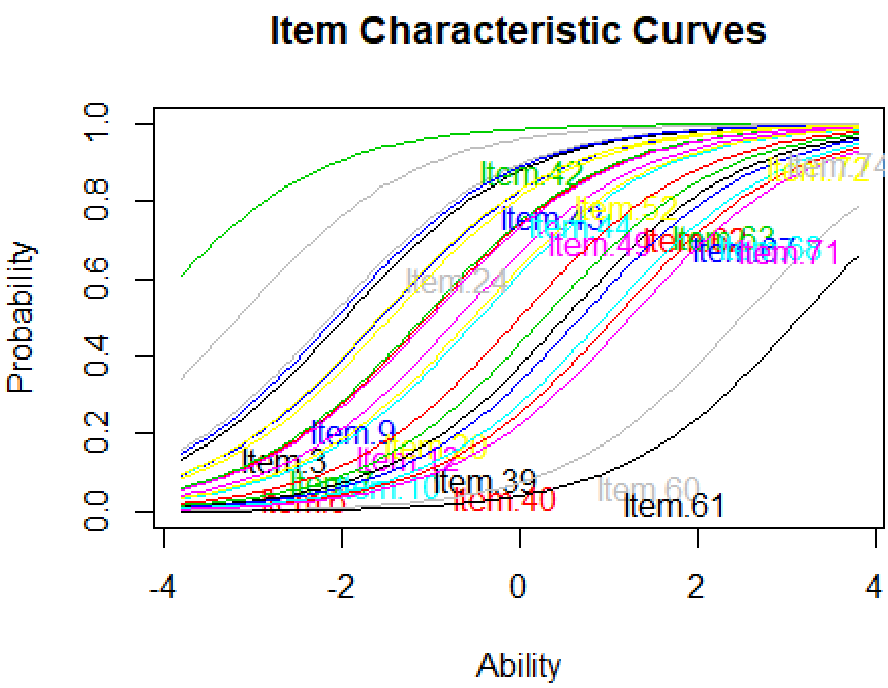
Appendix 65 – Item Difficulty, Standard Error, Round 7

```
## Coefficients:
##                    value std.err
## Dffclt.Item.3    -1.9586  0.1656
## Dffclt.Item.6    -1.0409  0.1495
## Dffclt.Item.7    -1.0776  0.1499
## Dffclt.Item.9    -1.5492  0.1571
## Dffclt.Item.10   -0.4495  0.1439
## Dffclt.Item.12   -0.6833  0.1457
## Dffclt.Item.20   -0.5212  0.1444
## Dffclt.Item.24   -2.1328  0.1700
## Dffclt.Item.39    0.5169  0.1419
## Dffclt.Item.40    1.0796  0.1455
## Dffclt.Item.42   -4.2422  0.2886
## Dffclt.Item.43   -2.0576  0.1681
## Dffclt.Item.44   -1.5704  0.1575
## Dffclt.Item.49   -1.0023  0.1490
## Dffclt.Item.52   -1.4421  0.1553
## Dffclt.Item.60    2.4999  0.1769
## Dffclt.Item.61    3.1551  0.2078
## Dffclt.Item.62    0.0035  0.1418
## Dffclt.Item.63    0.2777  0.1415
## Dffclt.Item.67    0.6894  0.1426
## Dffclt.Item.68    0.9533  0.1443
## Dffclt.Item.71    1.2451  0.1473
## Dffclt.Item.72   -1.5706  0.1575
## Dffclt.Item.74   -3.1620  0.2091
## Dscrmn            1.0000      NA
```

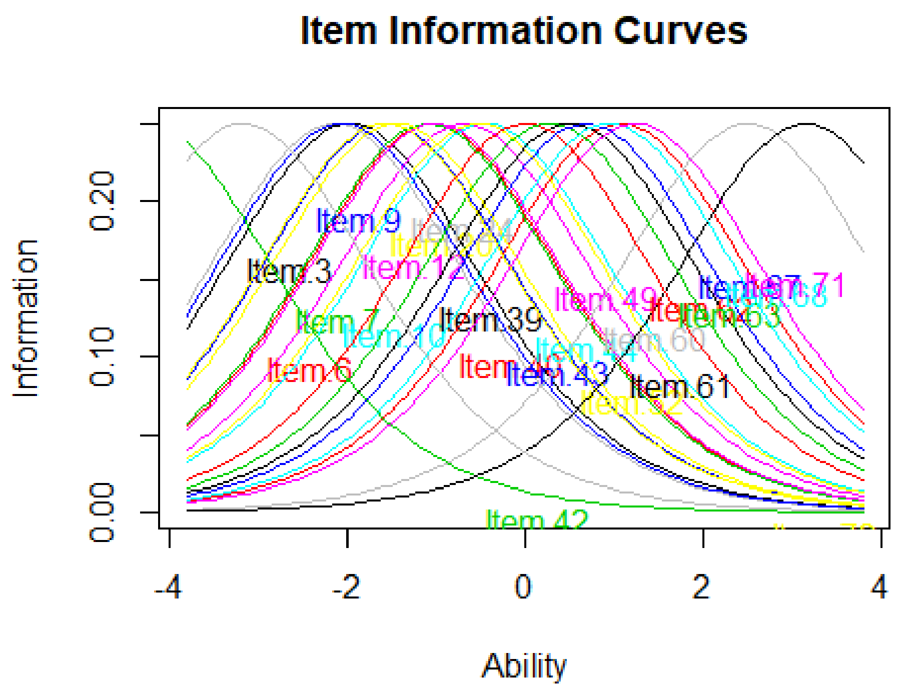
Appendix 66 – Item Difficulty, Conditional Maximum Likelihood, Round 7

```
## Item Easiness Parameters (beta) with 0.95 CI:
##               Estimate Std. Error lower CI upper CI
## beta Item.3      1.863      0.180    1.511    2.216
## beta Item.6      0.618      0.161    0.302    0.935
## beta Item.7      0.671      0.162    0.354    0.989
## beta Item.9      1.312      0.170    0.978    1.645
## beta Item.10    -0.185      0.154   -0.487    0.117
## beta Item.12     0.132      0.157   -0.175    0.439
## beta Item.20    -0.089      0.155   -0.392    0.215
## beta Item.24     2.095      0.185    1.733    2.458
## beta Item.39    -1.473      0.153   -1.772   -1.174
## beta Item.40    -2.221      0.160   -2.533   -1.908
## beta Item.42     4.760      0.320    4.134    5.387
## beta Item.43     1.994      0.183    1.636    2.352
## beta Item.44     1.341      0.171    1.006    1.675
## beta Item.49     0.566      0.161    0.251    0.881
## beta Item.52     1.167      0.168    0.838    1.497
## beta Item.60    -4.153      0.211   -4.567   -3.740
## beta Item.61    -5.053      0.260   -5.563   -4.542
## beta Item.62    -0.792      0.152   -1.089   -0.495
## beta Item.63    -1.156      0.152   -1.453   -0.858
## beta Item.67    -1.702      0.154   -2.004   -1.400
## beta Item.68    -2.053      0.157   -2.361   -1.744
## beta Item.71    -2.443      0.163   -2.762   -2.124
## beta Item.72     1.341      0.171    1.006    1.675
## beta Item.74     3.457      0.234    2.998    3.917
```

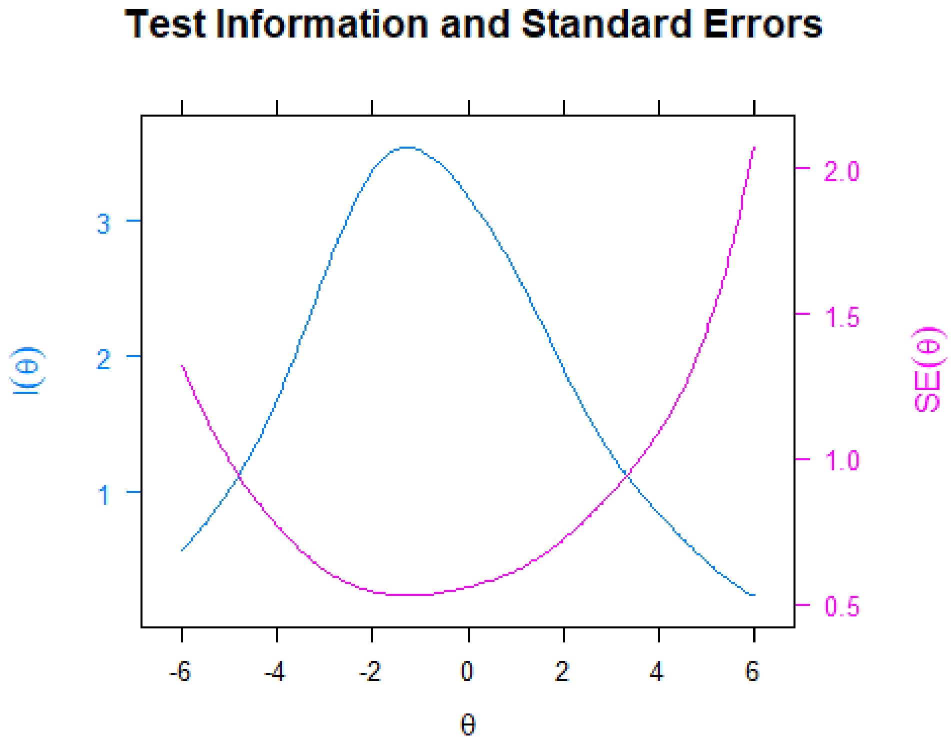
Appendix 67 – Plotted Item Characteristic Curves, Round 7



Appendix 68 – Plotted Item Information Curves, Round 7



Appendix 69 – Plotted Test Information Function, Round 7



Appendix 70 – Unidimensionality, Round 7

```
##          Item H   se
## Item.3    0.652 (0.037)
## Item.6    0.603 (0.035)
## Item.7    0.700 (0.028)
## Item.9    0.691 (0.032)
## Item.10   0.711 (0.027)
## Item.12   0.673 (0.031)
## Item.20   0.674 (0.031)
## Item.24   0.637 (0.046)
## Item.39   0.683 (0.029)
## Item.40   0.718 (0.028)
## Item.42   0.765 (0.060)
## Item.43   0.639 (0.038)
## Item.44   0.627 (0.036)
## Item.49   0.716 (0.027)
## Item.52   0.658 (0.033)
## Item.60   0.866 (0.024)
## Item.61   0.853 (0.037)
## Item.62   0.711 (0.027)
## Item.63   0.675 (0.030)
## Item.67   0.678 (0.032)
## Item.68   0.690 (0.031)
## Item.71   0.685 (0.033)
## Item.72   0.590 (0.037)
## Item.74   0.804 (0.048)
```

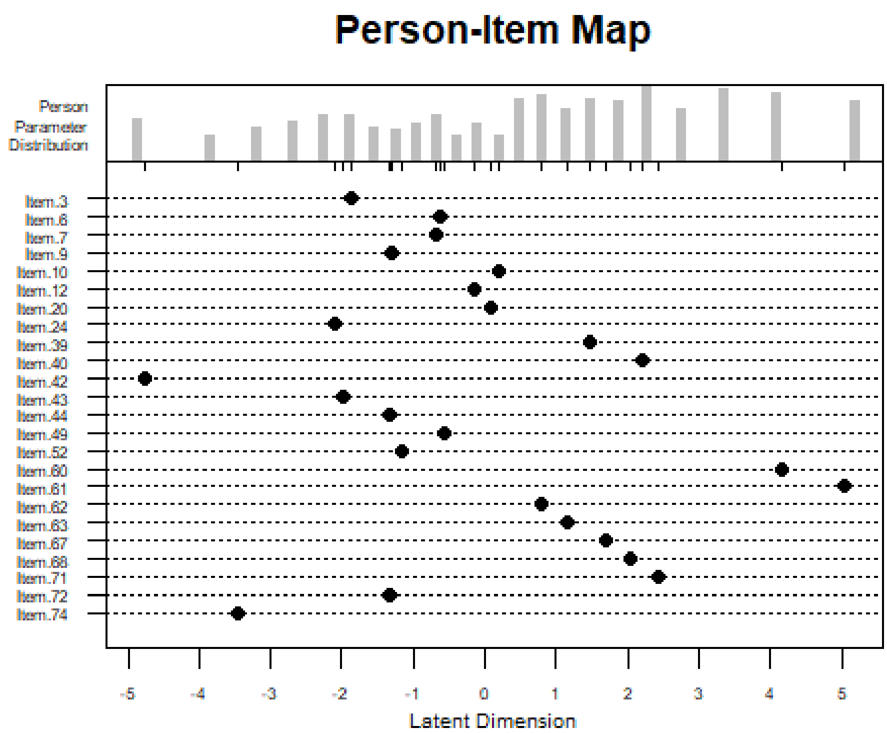
Appendix 71 – Monotonicity, Round 7

```
##          ItemH #ac #vi #vi/#ac maxvi sum sum/#ac zmax #zsig crit
## Item.3   0.65   6   0       0     0   0       0    0     0    0
## Item.6   0.60   6   0       0     0   0       0    0     0    0
## Item.7   0.70   6   0       0     0   0       0    0     0    0
## Item.9   0.69   6   0       0     0   0       0    0     0    0
## Item.10  0.71   6   0       0     0   0       0    0     0    0
## Item.12  0.67   6   0       0     0   0       0    0     0    0
## Item.20  0.67   6   0       0     0   0       0    0     0    0
## Item.24  0.64   6   0       0     0   0       0    0     0    0
## Item.39  0.68   6   0       0     0   0       0    0     0    0
## Item.40  0.72   3   0       0     0   0       0    0     0    0
## Item.42  0.77   1   0       0     0   0       0    0     0    0
## Item.43  0.64   3   0       0     0   0       0    0     0    0
## Item.44  0.63   6   0       0     0   0       0    0     0    0
## Item.49  0.72   6   0       0     0   0       0    0     0    0
## Item.52  0.66   6   0       0     0   0       0    0     0    0
## Item.60  0.87   1   0       0     0   0       0    0     0    0
## Item.61  0.85   2   0       0     0   0       0    0     0    0
## Item.62  0.71   3   0       0     0   0       0    0     0    0
## Item.63  0.67   3   0       0     0   0       0    0     0    0
## Item.67  0.68   6   0       0     0   0       0    0     0    0
## Item.68  0.69   3   0       0     0   0       0    0     0    0
## Item.71  0.69   3   0       0     0   0       0    0     0    0
## Item.72  0.59   6   0       0     0   0       0    0     0    0
## Item.74  0.80   3   0       0     0   0       0    0     0    0
```

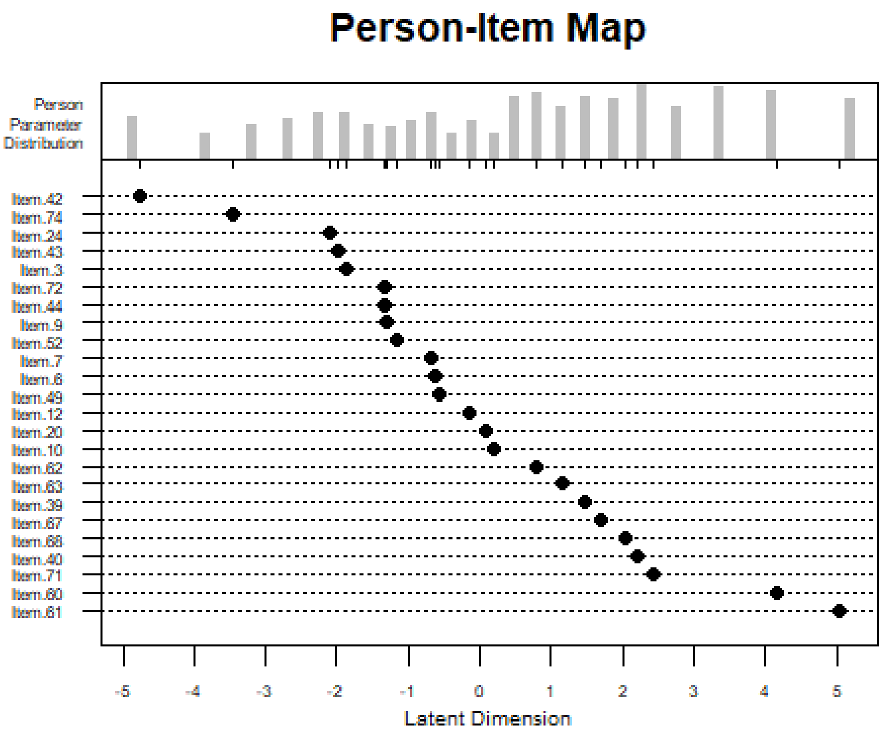
Appendix 72 – Invariant Item Ordering, Round 7

```
##          ItemH #ac #vi #vi/#ac maxvi sum sum/#ac zmax #zsig crit
## Item.42  0.76  69   0       0     0   0       0    0     0    0
## Item.74  0.80  69   0       0     0   0       0    0     0    0
## Item.24  0.64  69   0       0     0   0       0    0     0    0
## Item.43  0.64  69   0       0     0   0       0    0     0    0
## Item.3   0.65  69   0       0     0   0       0    0     0    0
## Item.72  0.59  69   0       0     0   0       0    0     0    0
## Item.44  0.63  69   0       0     0   0       0    0     0    0
## Item.9   0.69  69   0       0     0   0       0    0     0    0
## Item.52  0.66  69   0       0     0   0       0    0     0    0
## Item.7   0.70  69   0       0     0   0       0    0     0    0
## Item.6   0.60  69   0       0     0   0       0    0     0    0
## Item.49  0.72  69   0       0     0   0       0    0     0    0
## Item.12  0.67  69   0       0     0   0       0    0     0    0
## Item.20  0.67  69   0       0     0   0       0    0     0    0
## Item.10  0.71  69   0       0     0   0       0    0     0    0
## Item.62  0.71  69   0       0     0   0       0    0     0    0
## Item.63  0.68  69   0       0     0   0       0    0     0    0
## Item.39  0.68  69   0       0     0   0       0    0     0    0
## Item.67  0.68  69   0       0     0   0       0    0     0    0
## Item.68  0.69  69   0       0     0   0       0    0     0    0
## Item.40  0.72  69   0       0     0   0       0    0     0    0
## Item.71  0.68  69   0       0     0   0       0    0     0    0
## Item.60  0.87  69   0       0     0   0       0    0     0    0
## Item.61  0.85  69   0       0     0   0       0    0     0    0
```

Appendix 73 – Person-Item Map, Round 7



Appendix 74 – Person-Item Map Sorted, Round 7



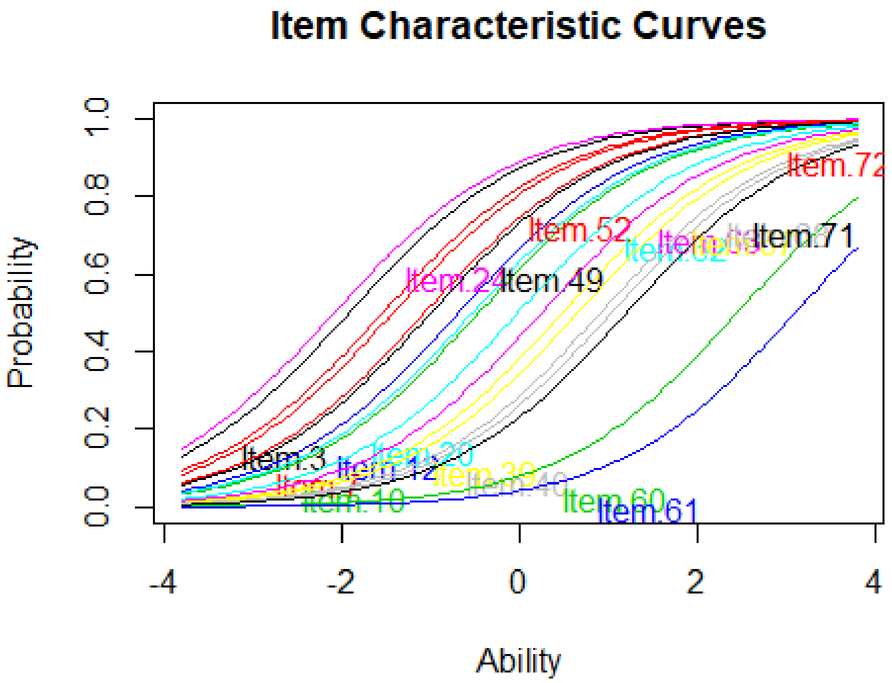
Appendix 75 – Item Difficulty, Standard Error, Selection

```
## Coefficients:
##                    value std.err
## Dffclt.Item.3    -1.9129  0.1628
## Dffclt.Item.7    -1.0663  0.1476
## Dffclt.Item.10   -0.4576  0.1420
## Dffclt.Item.12   -0.6845  0.1436
## Dffclt.Item.20   -0.5268  0.1424
## Dffclt.Item.24   -2.0802  0.1672
## Dffclt.Item.39    0.4856  0.1408
## Dffclt.Item.40    1.0397  0.1447
## Dffclt.Item.49   -0.9916  0.1467
## Dffclt.Item.52   -1.4162  0.1527
## Dffclt.Item.60    2.4512  0.1768
## Dffclt.Item.61    3.1047  0.2078
## Dffclt.Item.62   -0.0171  0.1403
## Dffclt.Item.63    0.2512  0.1402
## Dffclt.Item.67    0.6558  0.1416
## Dffclt.Item.68    0.9157  0.1435
## Dffclt.Item.71    1.2034  0.1467
## Dffclt.Item.72   -1.5394  0.1549
## Dscrmn            1.0000      NA
```

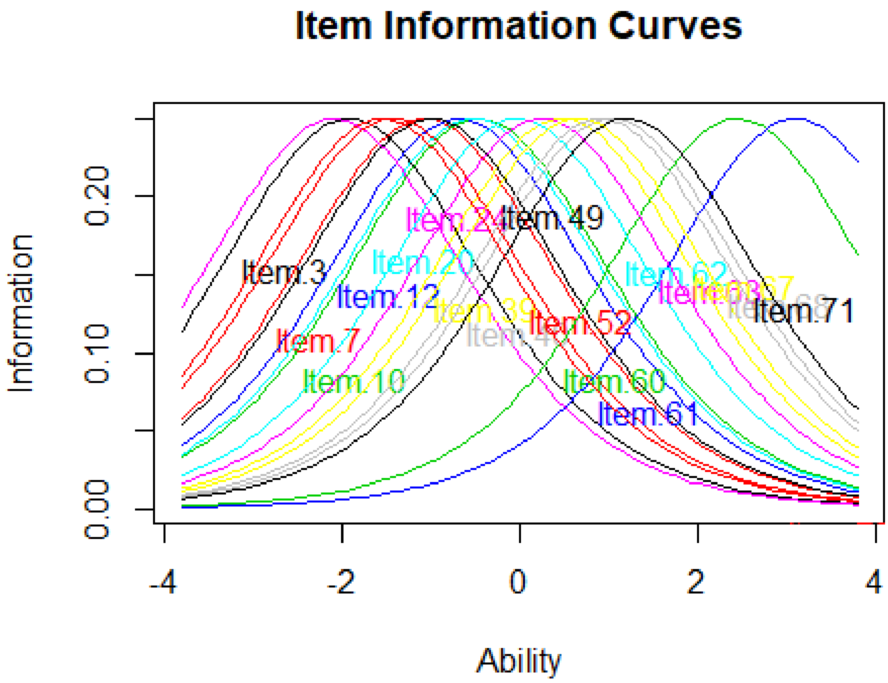
Appendix 76 – Item Difficulty, Conditional Maximum Likelihood, Selection

```
## Item Easiness Parameters (beta) with 0.95 CI:
##               Estimate Std. Error lower CI upper CI
## beta Item.3      2.679      0.188    2.310    3.048
## beta Item.7      1.428      0.165    1.105    1.752
## beta Item.10     0.546      0.154    0.244    0.848
## beta Item.12     0.870      0.158    0.561    1.179
## beta Item.20     0.644      0.155    0.340    0.948
## beta Item.24     2.922      0.195    2.540    3.304
## beta Item.39    -0.747      0.150   -1.041   -0.453
## beta Item.40    -1.493      0.156   -1.799   -1.186
## beta Item.49     1.318      0.164    0.998    1.639
## beta Item.52     1.948      0.173    1.608    2.288
## beta Item.60    -3.421      0.206   -3.825   -3.017
## beta Item.61    -4.317      0.255   -4.817   -3.817
## beta Item.62    -0.066      0.150   -0.360    0.228
## beta Item.63    -0.430      0.149   -0.722   -0.137
## beta Item.67    -0.975      0.151   -1.271   -0.679
## beta Item.68    -1.325      0.154   -1.627   -1.023
## beta Item.71    -1.714      0.159   -2.026   -1.402
## beta Item.72     2.131      0.177    1.784    2.477
```

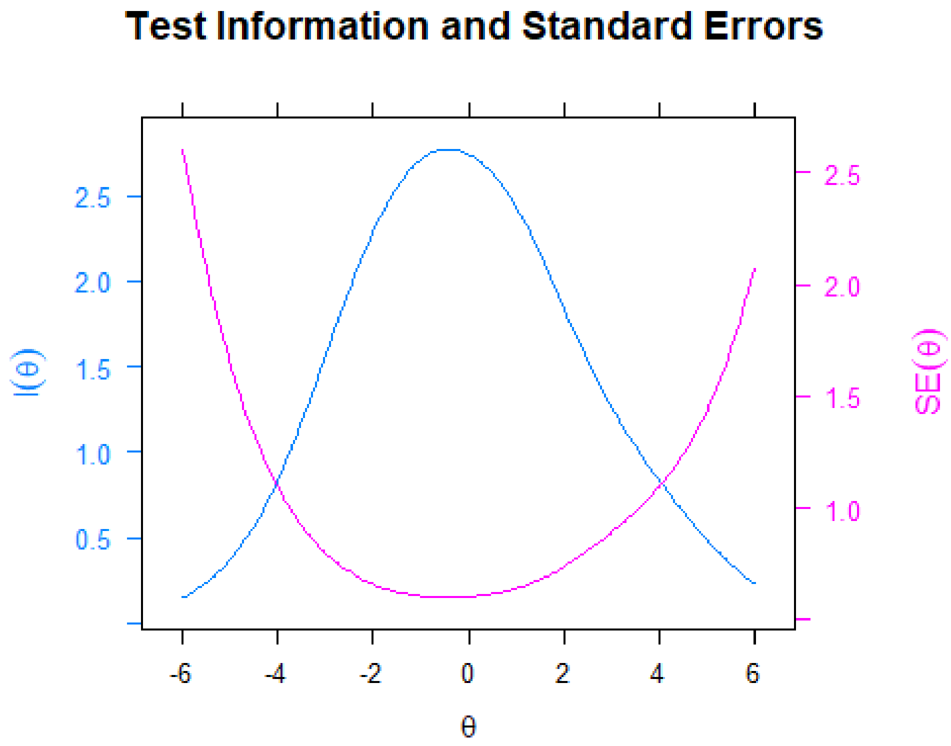
Appendix 77 – Plotted Item Characteristic Curves, Selection



Appendix 78 – Plotted Item Information Curves, Selection



Appendix 79 – Plotted Test Information Function, Selection



G

Appendix 80 – Unidimensionality, Selection

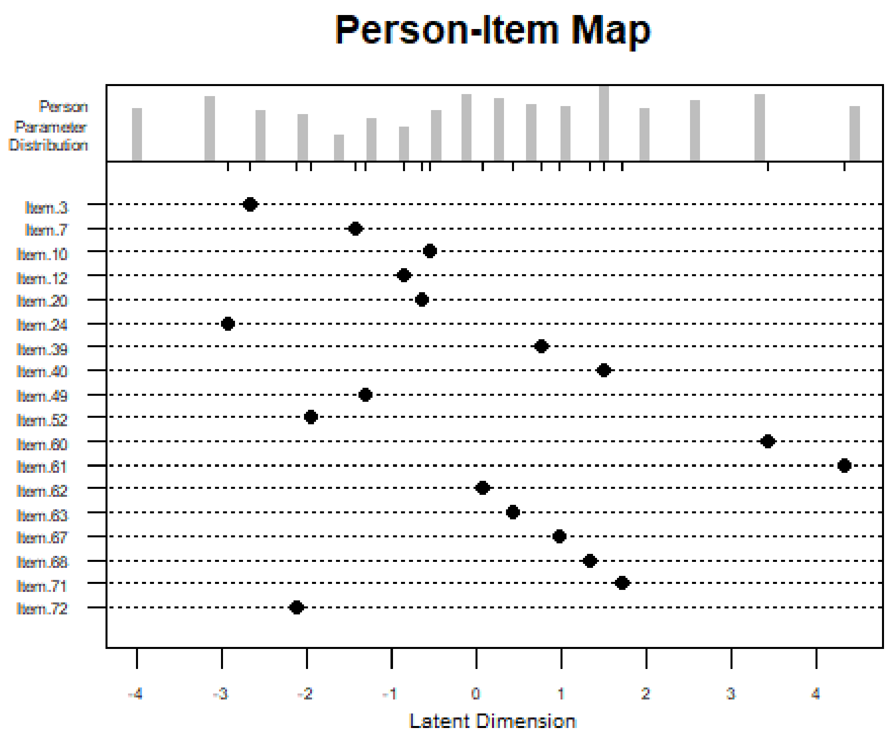
```
##          Item H   se
## Item.3    0.704 (0.040)
## Item.7    0.723 (0.030)
## Item.10   0.700 (0.028)
## Item.12   0.667 (0.033)
## Item.20   0.668 (0.032)
## Item.24   0.664 (0.049)
## Item.39   0.651 (0.031)
## Item.40   0.689 (0.029)
## Item.49   0.730 (0.028)
## Item.52   0.695 (0.035)
## Item.60   0.853 (0.026)
## Item.61   0.835 (0.042)
## Item.62   0.696 (0.028)
## Item.63   0.658 (0.031)
## Item.67   0.664 (0.031)
## Item.68   0.670 (0.031)
## Item.71   0.663 (0.034)
## Item.72   0.657 (0.037)
```

```
##          ItemH #ac #vi #vi/#ac maxvi sum sum/#ac zmax #zsig crit
## Item.3   0.70   6   0       0     0   0       0    0     0    0
## Item.7   0.72   6   0       0     0   0       0    0     0    0
## Item.10  0.70   6   0       0     0   0       0    0     0    0
## Item.12  0.67   6   0       0     0   0       0    0     0    0
## Item.20  0.67   6   0       0     0   0       0    0     0    0
## Item.24  0.66   3   0       0     0   0       0    0     0    0
## Item.39  0.65   6   0       0     0   0       0    0     0    0
## Item.40  0.69   3   0       0     0   0       0    0     0    0
## Item.49  0.73   6   0       0     0   0       0    0     0    0
## Item.52  0.69   6   0       0     0   0       0    0     0    0
## Item.60  0.85   1   0       0     0   0       0    0     0    0
## Item.61  0.83   3   0       0     0   0       0    0     0    0
## Item.62  0.70   3   0       0     0   0       0    0     0    0
## Item.63  0.66   6   0       0     0   0       0    0     0    0
## Item.67  0.66   6   0       0     0   0       0    0     0    0
## Item.68  0.67   6   0       0     0   0       0    0     0    0
## Item.71  0.66   3   0       0     0   0       0    0     0    0
## Item.72  0.66   6   0       0     0   0       0    0     0    0
```

Appendix 82 – Invariant Item Ordering, Selection

```
##            ItemH #ac #vi #vi/#ac maxvi sum sum/#ac zmax #zsig crit
## Item.24  0.66  51   0       0     0   0       0    0     0    0
## Item.3   0.70  51   0       0     0   0       0    0     0    0
## Item.72  0.66  51   0       0     0   0       0    0     0    0
## Item.52  0.70  51   0       0     0   0       0    0     0    0
## Item.7   0.72  51   0       0     0   0       0    0     0    0
## Item.49  0.73  51   0       0     0   0       0    0     0    0
## Item.12  0.67  51   0       0     0   0       0    0     0    0
## Item.20  0.67  51   0       0     0   0       0    0     0    0
## Item.10  0.70  51   0       0     0   0       0    0     0    0
## Item.62  0.70  51   0       0     0   0       0    0     0    0
## Item.63  0.66  51   0       0     0   0       0    0     0    0
## Item.39  0.65  51   0       0     0   0       0    0     0    0
## Item.67  0.66  51   0       0     0   0       0    0     0    0
## Item.68  0.67  51   0       0     0   0       0    0     0    0
## Item.40  0.69  51   0       0     0   0       0    0     0    0
## Item.71  0.66  51   0       0     0   0       0    0     0    0
## Item.60  0.85  51   0       0     0   0       0    0     0    0
## Item.61  0.84  51   0       0     0   0       0    0     0    0
```

Appendix 83 – Person-Item Map, Selection



Appendix 84 – Person-Item Map Sorted, Selection