ORIGINAL ARTICLE

Development of the "Playing-in-Touch" (PiT) questionnaire: a measure of musical intouchness in people with low-functioning autism

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Abstract

BACKGROUND: There is accumulating evidence that people with autism have a particular affinity with music. **METHODS:** This study developed the "Playing-in-Touch" (PiT) questionnaire as an objective measure of musical intouchness – defined as the degree of engagement in creative exchange while playing ensemble music pieces – in persons with low-functioning autism. **RESULTS:** A 3-facet Rasch model supported the content and construct validity of the PiT scale. The items verified a one-dimensional hierarchical model. **CONCLUSIONS:** The PiT questionnaire is a convenient complement to other research methodologies exploring the attitudes of people with low-functioning autism in terms of active music making.

Introduction

Growing evidence suggests that people with autistic spectrum disorders (ASD) have a particular affinity with music (Boso *et al* 2010; Heaton *et al* 2007). Individuals with autism may exhibit absolute pitch (Bonnel *et al* 2003; Heaton 2005; 2008a;b), rhythm oddities (Grandin 2006), and savant music skills (Bonoldi *et al* 2009; Heaton & Wallace 2004; Young & Nettelbeck 1995). Evidence from high-functioning adults on the autism spectrum indicates that they may display intense emotional arousal responses to music (Allen *et al* 2009). In addition, music provides a unique and powerful means of promoting communication and social interaction in persons with ASD (Waldon & Wolfe 2006; Wigram & Gold 2006).

The "Invisible Orchestra" – established in 2005 – is an ensemble consisting of both persons with low-functioning autism and Medical Faculty Staff that specializes in performing jazz standards. The role of ASD persons within the orchestra is to play percussion instruments. Preliminary observations by the Faculty Staff during playing sessions suggest that individuals with autism are able to keep proper time being in the groove with the entire band (personal communication). Despite evidence indicating that music can be a creative outlet in addition to helping regulate behavior in persons with ASD (Waldon & Wolfe 2006; Wigram & Gold 2006), few attempts have been made to provide a detailed analysis of musical phenomena and attitudes in this neurodevelopmental disorder. In a qualitative study involving the microanalysis of the music

therapy process, Holck (2007) demonstrated the chain of musical interaction between the autistic child and the music therapist through detailed, time-based documentation of facial expression (smile), eye contact, and the initiatives of the child with well-timed responses of the therapist to the child's musical expression. Recently, Welch *et al* (2009) developed the Sounds of Intent, an original framework for mapping the behaviour and development in, and through, music for children with complex needs and profound learning difficulties. The Sounds of Intent tool may be used to assess the musical development of children with complex needs and to enable children's progress to be recorded directly using a small digital video camera.

Although persons with autism do not readily engage in positive affect exchanges with others in social situations and show difficulties in the social-affective area, accumulating evidence has suggested that music is a form of communication that may be of special importance for and from the autistic spectrum (Bonoldi *et al* 2009; Heaton *et al* 2007). This study developed the "Playing-in-Touch" (PiT) questionnaire as an objective measure of musical intouchness – defined as the degree of engagement in creative exchange while playing ensemble music pieces – in persons with low-functioning autism. To obtain an objective measurement, we developed an instrument according to the criteria of the Rasch measurement model (Wright & Mok 2000). The PiT is designed as a simple and convenient complement to other research methodologies exploring the musical attitudes of people with autism.

Materials and methods

Setting and orchestra

The "Invisible Orchestra" consists of 12 persons with severe low-functioning autism (8 males and 4 females, age range: 18 to 38 years, mean: 29.4 years, standard deviation: 6.9 years; Raven's Progressive Matrices mean score: 13.3, standard deviation: 7.4; CARS scores ranging from 32 to 49, mean: 40.2, standard deviation: 7.8) and 10 members of the Medical Faculty Staff of the University of Pavia, Pavia, Italy. All members from the Faculty Staff earned a MD degree and are Staff Psychiatrists or Resident in Psychiatry at the same University. In addition, they all are amateur musicians playing the piano, double-bass, alto and tenor sax, trumpet, and trombone. Persons with autism play drums, congas, xylophone, bongos, shaker, and tambourine. The orchestra repertoire include a selection of mainstream or evergreen jazz standards such as "Nostalgia in Times Square", "Blue Monk", "My Funny Valentine", "and "Stella By Starlight". The approach to performing consisted of alternating written music with improvisation. The Orchestra meets weekly for two hours on Friday afternoon (3:00–5:00 PM) in Cascina Rossago (Pontenizza, Italy), a residential farm community for individuals with low-functioning autism. The diagnosis of ASD was confirmed jointly by two independent psychiatrists specializing in autism spectrum disorders according to the guidelines of the Structured Clinical Interview for Axis I DSM-IV-TR Disorders, Patient Version. In addition, all patients met ADI-R criteria for autism.

Video recording

After a run-in period of 20 sessions (approximately 5 months) with the aim of making ASD patients familial with jazz standards, each subject was video recorded using high-tech cameras while playing Charles Mingus's "Nostalgia in Time Square". Therefore, a total of 12 videos (one for each subject) was used for the purpose of analysis. All parents/legal guardians gave their informed consent to both recording and using video material.

Raters

Twenty-three raters (10 males and 13 females, mean age: 23.3±2.1 years) examined the study videotapes. The raters were students from the University of Pavia, Pavia, Italy. The raters were required to have at least three years of individual music education. The raters subjectively assessed all videotapes in an independent manner, producing a total of 276 records (12 videotapes analyzed by 23 raters). All raters were asked to carefully watch the video of each person with autism during the music session, and fill the PiT questionnaire according to their own judgement.

Questionnaire

We initially hypothesized that the PiT questionnaire would display a single general construct with unknown subscales (dimensions). In the beginning, we selected – based on their content potentially relating to intouchness – a total of 46 items measured on a 5-point Likert scale (from 1 = never to 5 = always). Items were constructed into a questionnaire according to the following procedure: eleven items were translated from the Sounds of Intent (Welch *et al* 2009); five items were adapted from the same instrument; seven were derived from the Assessment of the Quality of Relationship (AQR) instrument (Schumacher & Calvet 2007), five were modified from PDD Behavior Inventory (Cohen *et al*2003), and the remaining items were independently constructed by the authors based on their own experience with active music playing together with people with low-functioning ASD. A pilot study on 4 random videos rated by the 23 assessors (92 units) using Principal Component Analysis/Multiple Correspondence Analysis (PCA/MCA) indicated that the Likert-style responses were not appropriate, the items were multidimensional (three dimensions), and there were highly redundant or overlapping item contents (data not shown). Thus, for the purpose of this study, we designed a shortened 16-item version with a binary format (1 = yes, and 0 = no). Nine items were positively worded, while the remaining 7 items negatively worded (***Table 1***).

Rasch analysis

Rasch model is a two-facet latent trait model designed to simultaneously estimate both item difficulty and the test-taker performance on the same unidimensional latent trait. The many-facet Rasch model introduces other factors that may be uniquely ordered on the latent trait. In the present study, we used a three-facet Rasch model (Linacre 1989). The three facets were (a) the videotaped music performance of the patient, (b) the level of the item hierarchy, and (c) the rater's assessment, that we assumed to be on a metric scale of musical "intouchness". In brief, the model is an additive linear model where the facets were considered as explanatory variables, and the logit of the success probabilities was the response variable. The logits (i.e. log-odds) are the logarithm of the ratio of probability to succeed or fail on a task. This model makes restrictive assumptions of measurement: each facet must be on a common (unidimensional) construct, have an equal discrimination, and display a hierarchical ordering. Therefore, the test of fit to the Rasch model is equivalent to checking whether the instrument fits rigorous measurement prescriptions of construct validity (Baghaei 2008). Besides the facet parameters, several Rasch fit statistics may be used. For the purpose of this study, we used the Andersen's likelihood ratio test (LRT) within each videotape, and the residual (observed-fitted) based INFIT and OUTFIT statistics. A LRT significance level of $p>0.05$ was considered as acceptable for the overall goodness-of-fit. On the other hand, INFIT/OUTFIT values outside the range 0.4–1.6 were used to identify the videotapes, the questionnaire items, and the raters that failed to fit with the model assumptions (Wrigth & Linacre 1984). The rater consistency (homogeneity) was assessed using the intraclass correlation (ICC) index. The ICC was calculated as the variance between videotapes divided for the variance between videotapes plus the variance within videotapes. The smaller the within-videotape variance, the greater the homogeneity of the assessment of the raters. An ICC >0.7 was considered to indicate a similar calibration for each rater during assessment of videotapes. The rater, item, and video parameters were displayed in the same figure, termed the Rasch map. The location of the raters shows the homogeneity of the raters' evaluations, that of the items the hierarchical difficulty of the items temselves, while the location of the videotapes represents the global patient performance. Therefore, independently from the raters' evaluation, the location of items and videotapes on the Rasch map stands for the difference between the patient's performance and the item difficulty (p–d). If the patient performance shows a higher level of playing-intouchness compared with the item difficulty (p>d), then the individual is expected to perform the task successfully. The higher the difference, the higher the probability of an in-touch performance. Conversely, if the patient performance is lower than the item difficulty (p<d), then the person will be expected to fail in performing the task. The bigger the difference, the lower the probability of successful performance. When the patient's level equates the item's level (p=d) then the outcome is very uncertain, and the probability of a successful performance is 0.5. The Mplus package, version 6.1 (Mplus software, Los Angeles, CA, USA), implementing a general hierarchical multi (between-within) level framework modelling via marginal maximum likelihood estimation (MMLE) procedure, was used for computing the three-facet Rasch models.

Tab. 1. Frequency distributions of positive response (yes = 1 for direct items, no = 1 for reversal items) of the PiT questionnaire in the raters × videos sample (N = 23 × 12= 276).

Item	Label	Number	Percent
PiT01	Listens and responds to different sounds	228	82.6%
PiT02	Plays spontaneously	223	80.8%
PiT03*	Distracted	174	64.5%
PiT04	Moves him/herself on time	134	48.6%
PiT05*	Looks as not in touch	181	67.0%
PiT06	Introduces original rhythmical patterns	78	28.3%
PiT07*	Plays in a repetitive, flat way	135	50.4%
PiT08	Follows the rhythm	170	61.6%
PiT09	Totally involved in the group	187	67.8%
PiT10	Makes a variety of sounds	73	26.4%
PiT11*	Makes sounds accidentally	197	72.8%
PiT12	Watch the others players	204	73.9%
PiT13*	Plays in a stereotyped way	131	48.9%
PiT14*	Plays only if prompted	227	83.7%
PiT15*	Free rhythm, not referable to any scheme	184	68.1%
PiT16	Keeps the time, with some liberties	187	67.8%

PiTxx*, items with reverse wording

Results

A series of Rasch analysis of the 16 items of the PiT questionnaire assessed by the 23 raters for a total of 12 videos (276 units) indicates that six items (PiT09, PiT11*, PiT12, PiT13*, PiT14*, PiT15*) should be excluded as they did not fit with the three-facet Rasch model. The model estimates (MMLE) and the fit statistics of the shortened 10-item final set are presented in ***Table 2***. The final PiT questionnaire is reported in the Appendix 1. The results of the Anderson goodness-of-fit tests for within-videotape ratings ranged between 5.54 (p=0.699) and 7.82 (p=0.552), suggesting that the data fitted the three-facet Rasch model.

The results of individual fit statistics showed that the item INFIT values ranged between 0.694 and

Tab. 2. Parameter estimates (MMLE) and INFIT/OUTFIT statistics of the 10-item of PiT questionnaire.

Items	Estimate	SE	Strata	OUTFIT	INFIT
PiT01	1.618	0.194	1	0.522	0.839
PiT02	1.470	0.13	2	0.711	1.048
PiT16	**0.573**	0.135	3	0.545	0.694
PiT05*	**0.528**	0.222	3	0.840	0.931
PiT03*	0.374	0.203	4	1.132	1.140
PiT08	0.202	0.11	5	0.788	0.766
PiT07*	0.450	0.19	6	1.374	1.272
PiT04	0.555	0.238	7	1.119	1.071
PiT06	1.816	0.159	8	0.837	0.804
PiT10	1.943	0.193	9	1.899	1.259

MMLE, Marginal Maximum Likelihood Estimate; SE, Standard Error; Strata, number of strata defined by item separation >0.10 logit; OUTFIT, standardized residuals summarized as unweighted mean squares; INFIT, standardized residuals summarized as weighted mean squares.

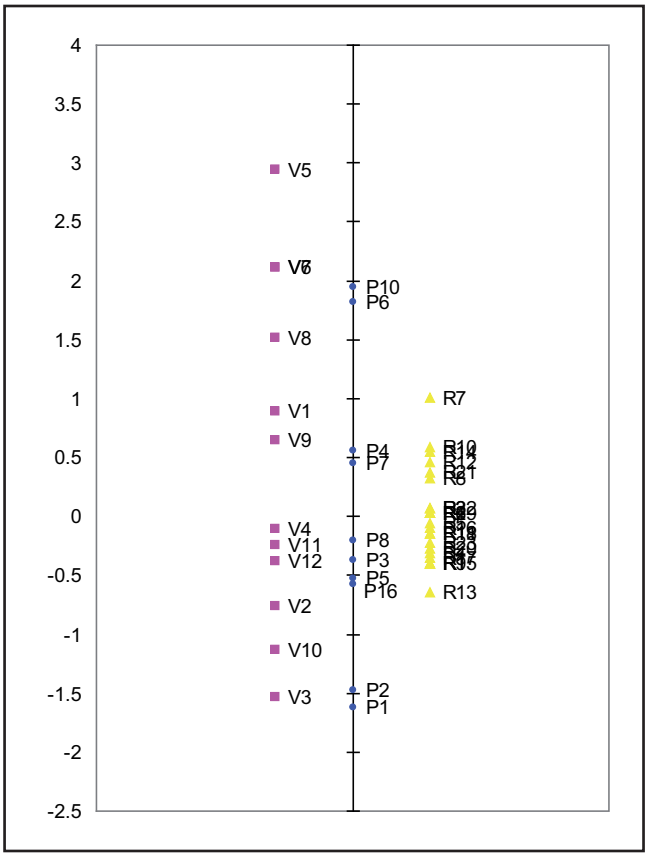

Fig. 1. Rasch map of videotapes, raters, and items from three-facet model of PiT questionnaire.

1.272, which were inside the reference range (0.4–1.6). These indices suggest that the 10-item version of the questionnaire had a unidimensional construct (i.e. intouchness), without either inter-rater and within-videotape underfitting (redundant or overlapping content areas) or overfitting (high residuals of observed vs. corresponding predicted values). In contrast, the item OUTFIT values showed a higher variability, ranging from 0.522 to 1.899. Only the PiT10 item ("Makes a variety of sounds"=1.899) was an outlier, indicating the presence of overfitting. The estimates of overlap in the distribution of item difficulties (hierarchy) – i.e., a item separation smaller than 0.10 logit (scale's measurement standard error) for item successive differences – was equal to one locations (PiT05–PiT16). These results suggest that these 10 items are actually separated at different levels on the underlying continuum of the PiT latent variable.

The overall mean calibration of the videotapes was 0.519, suggesting a satisfactory targeting of item in terms of difficulty among raters. It should be noted that the average item and the rater calibrations for the three-facet parameter estimation are fixed to zero. Additionally, intraclass correlation (ICC) was equal to 0.91. The INFIT/OUTFIT residual statistics across videotapes and raters indicated that there were only one exception (R7) among the 23 raters (outside the 0.4–1.6 range), thereby misfitting the PiT construct.

Figure 1 displays on the PiT latent trait the three-facet map of the item calibrations, videotape, and raters locations, and their spread in relation to each other, in logit units. A lower rater's locations separation (from about –0.5 to +0.5 logit) exhibits a similarly homogenous inter-rater assessment. The videotape depicting the less-in-touch patient (V3) obtained the worst sum score (average rater raw score of 2.35) and was given the lowest logit value (–1.537). This patient was thus located at the bottom. In contrast, the videotape showing the more-in-touch patient (V5) yielded the best sum score (average rater raw score of 9.13) and obtained the highest logit value (+2.943). The remaining patient videotapes were placed between about –1 and +2 logits. The items locations were in agreement with patients video's spread and varied between –1.6 (item PiT01, i.e. "Listens and responds to different sounds" was the easiest item (82.3% of positive response) and +2.0 logits (with item PiT10, i.e. "Makes a variety of sounds", being the item of highest difficulty: 26.4% of positive response).

In summary, the results of the Rasch analysis suggested that the 10 items of the PiT questionnaire verified a one-dimensional model, and that the ordering of the items followed a reasonable hierarchy. Additionally, the Rasch map can be considered a convenient tool to visualize both patient videotape performance and rater assessments on the same continuum scale.

Discussion

This paper describes the development of the PiT questionnaire, a specific measure of musical intouchness – defined as the degree of engagement in creative exchange through ensemble music pieces – in persons

with autism. The PiT instrument is built on the Rasch paradigm stating that the model should be used for examination of data, not for description of data, i.e. it is recommended to find a set of items that satisfies the model measurement assumptions rather than find a model that fit an existing item set (Hagquist 2001).

The output of three-facet (videotapes, raters, and items) Rasch analysis showed that the 10-item set was one-dimensional (item fit statistics within the range of 0.4–1.6), suggesting that all items shared the latent trait underlying the intouchness construct. The item order is theoretically reasonable on the intouchness continuum with an item hierarchy from the bottom level of "Listens and responds to different sounds" through the middle level of "Looks as not in touch" to the top of "Makes a variety of sounds" (***Figure 1***). Additionally, the raters' agreement (intraclass correlation of 0.91) consistently assessed the underlying construct of the PiT questionnaire (out of the 23 raters, only 1 was an outlier). These results indicate a low heterogeneity of videotape assessment, and a low discordance in item scaling.

To the best of our knowledge, the PiT questionnaire is the first psychometric index specifically designed to assess the musical intouchness of persons with autism. This instrument consists of a written questionnaire that independent raters should fill out after watching a videotape of a person with autism while playing percussive instruments within a jazz orchestra.

Growing evidence suggests that music may be an effective means of increasing communication skills of persons with autism. Most previous work in this area was in the field of music therapy. A recent meta-analysis of the Cochrane Library (Gold *et al* 2006) evaluated three randomized clinical trials (Brownell 2002; Buday 1995; Farmer 2003) aimed to investigate the effects of music therapy in the field of autism. These studies were designed to assess gesture or verbal communicative skills during each therapy sessions or, alternatively, behavioral improvements by means of *ad hoc* psychometric instruments. The combined results of these studies suggested that music therapy is better than placebo for improving verbal and gestural communicative skills, while no significant effects on behavioral problems were seen. The authors concluded that current evidence suggests that music therapy may help individuals with autism to improve their communicative skills. Whether the effects of music therapy are enduring remains to be determined.

Recent years have witnessed an increasing interest in the study of musical cognition in persons with autism (Heaton & Allen 2009). Specifically, autism does not appear to limit the extent to which individuals can derive benefits from the experience of listening to music. In addition, we have previously shown that subjects with severe autism share with healthy people the same musical preferences (Boso *et al* 2009). In order to study the smaller response to music stimuli in individuals with autism, a novel methodology – termed music microanalysis – has been developed. Microanalysis refers to the detailed analysis of events in music therapy sessions using verbal, musical and/or video data (Holck 2007). By using the tools of microanalysis, Kim and coworkers (2008) investigated the effects of improvisational music therapy on joint attention behaviors in pre-school children with autism. Video analysis of sessions showed significantly more and lengthier events of eye contact and turn-taking in improvisational music therapy than play sessions.

In the present study, we deliberately took a different approach to the issue of music experience in persons with severe autism. In particular, we sought to investigate the degree of engagement in creative exchange while playing ensemble music pieces through the development of the PiT questionnaire using Rasch analysis. Our psychometric instrument fitted the requirements related to the assumption of a Rasch model with good evidence of unidimensionality, and hierarchical item appropriateness of scaling. This scale has the advantage of being brief and focused on a relatively unexplored dimension of making music with others in persons with autism. Of note, the PiT can be used to assess the intouchness of each person with autism regardless of his/her specific music training and/or skills.

Some caveats are inherent in the present study. A limitation of our report is the homogeneity of the sample that could limit the generalizability of the findings. Another issue that should be considered is that the PiT questionnaire was not specifically developed to be used in a music therapy setting. Further studies are needed to shed more light on this issue.

In summary, the PiT questionnaire shows good psychometric properties and will make a convenient complement to other research methodologies exploring the musical attitudes of people with autism. Rasch analysis supported the content and construct validity of the questionnaire. The items verified a one-dimensional Rasch model, and were hierarchical.

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Appendix 1. PiT – PLAYING IN TOUCH QUESTIONNAIRE

Name_____ Date_____

Age_____ Gender: M / F

Video_____

The following questionnaire assesses how a person with autism is engaged within a jazz orchestra. Please watch carefully the video and thereafter circle your evaluation:

Plays spontaneously	yes	no
Plays in a flat, repetitive way *	yes	no
Listens and responds to different sounds	yes	no
Looks as not in touch *	yes	no
Keeps the time, with some liberties	yes	no
Introduces original rhythmical patterns	yes	no
Moves him/herself on time	yes	no
Distracted *	yes	no
Follows the rhythm	yes	no
Makes a variety of sounds	yes	no

Thank you! The Invisible Orchestra project (www.cascinarossago.it)