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Revealing interdyad differences in naturally occurring staff reactions to challenging behaviour of clients with severe or profound intellectual disabilities by means of Clusterwise Hierarchical Classes Analysis (HICLAS)

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Abstract

Background Investigating interdyad (i.e. couples of a client and their usual caregiver) differences in naturally occurring patterns of staff reactions to challenging behaviour (e.g. self-injurious, stereotyped and aggressive/destructive behaviour) of clients with severe or profound intellectual disabilities is important to optimise client–staff interactions. Most studies, however, fail to combine a naturalistic setup with a person-level analysis, in that they do not involve a careful inspection of the interdyad differences and similarities.
Method In this study, the recently proposed Clusterwise Hierarchical Classes Analysis (HICLAS) method is adopted and applied to data of in which video fragments (recorded in a naturalistic setting) of a client showing challenging behaviour and the staff reacting to it were analysed. In a Clusterwise HICLAS analysis, the staff–client dyads are grouped into a number of clusters and the prototypical behaviour–reaction patterns that are specific for each cluster (i.e. interdyad differences and similarities) are revealed.
Results Clusterwise HICLAS discloses clear interdyad differences (and similarities) in the prototypical patterns of clients' challenging behaviour and the associated staff reactions, complementing and qualifying the results of earlier studies in which only general patterns were disclosed.
Conclusions The usefulness and clinical relevance of Clusterwise HICLAS is demonstrated. In particular, Clusterwise HICLAS may capture idiosyncratic aspects of staff–client interactions, which may stimulate direct support workers to adopt person-centred support practices that take the specific abilities of the client into account.

Keywords clustering dyads, Clusterwise HICLAS, individual/interdyad differences, observation study in a naturalistic setting, prototypical patterns of challenging behaviours and staff reactions, severe or profound intellectual disabilities

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Introduction

Investigating how direct support workers respond to challenging behaviours, like aggression, stereotyped

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and self-injurious behaviour, of people with severe or profound intellectual disabilities (ID) is an interesting topic of research, as the social consequences of challenging behaviour may enforce/reinforce it (Carr 1977; Hastings & Remington 1994; Iwata *et al.* 1994; Oliver 1995; Thompson & Iwata 2001). However, this type of research is faced with two serious challenges.

First, the exhibited staff reactions may strongly vary across client–staff member dyads (i.e. couples of a client and their usual caregiver) as these reactions are influenced by individual differences between staff members and clients. With respect to staff members, staff reactions may be shaped by staff well-being, emotions, beliefs and attitudes (Rose *et al.* 1998; Hastings 2005; Lambrechts *et al.* 2008, 2009; Willner & Smith 2008). Regarding clients, persons with severe or profound ID differ a lot in their cognitive, communicative, social and emotional capabilities and limitations (Olsson 2005; Petry & Maes 2007; Lambrechts *et al.* 2008) and the functionality (i.e. the purpose of the behaviour) and expression of their challenging behaviour may vary accordingly. Moreover, staff members may react differently to similar challenging behaviour of different clients (Borthwick-Duffy 1994; Wachs 2000; Emerson 2001). Given these individual differences, it seems wise to undertake a person-level analysis of challenging behaviour–staff reaction patterns (i.e. the *if* challenging behaviour *then* staff reaction rules that characterise a certain dyad), as a group-level analysis may not reveal or even mask the most important patterns (Magnusson & Allen 1983; Light 1999). Also, a group-level analysis may neglect more idiosyncratic behaviour–reaction patterns of staff–client dyads, hampering the development of person-centred support practices that are tuned to the specific abilities (instead of disabilities) of each client.

Second, several authors criticise the use of interviews (e.g. Hastings 1995) or questionnaires (see, Hastings 1996; Saloviita 2002; Lambrechts *et al.* 2009) for studying behaviour–reaction patterns because of the bias that these methods may introduce (e.g. social desirable answers). As a solution, several authors advocate directly observing staff reactions to client's challenging behaviour in naturalistic settings (Iwata *et al.* 1994; Wilson *et al.* 1995; Hastings & Brown 2000; Thompson & Iwata 2001; Vollmer *et al.* 2001; Bailey *et al.* 2002; Paclawskyj *et al.* 2004; Oliver *et al.* 2005). This, however, is a complex task, among others, because the observed behaviour of both clients and staff has to be coded.

Although many studies have focused on staff reactions to challenging behaviour, most of them do not combine a naturalistic set-up with a careful inspection of whether and how behaviour–reaction patterns differ across dyads. This may be due to the lack of data-analytical techniques that allow for a fine-grained yet parsimonious analysis of these differences. Therefore, the goal of this paper is to demonstrate the added value of a recently developed method, called Clusterwise HICLAS (Wilderjans *et al.* 2012a). Clusterwise HICLAS simultaneously determines the prototypical behaviour–reaction patterns of each dyad and clusters the dyads based on these patterns. The cluster-specific prototypical patterns yield a parsimonious overview of the differences and similarities between dyads in challenging behaviour–staff reaction patterns.

To illustrate the usefulness of Clusterwise HICLAS, we will apply it to data collected by Lambrechts *et al.* (2010) and compare our person-level results with their group-level patterns. The data consist of video fragments (recorded in a naturalistic setting) of a client, which has a severe or profound ID, showing challenging behaviour and a staff member reacting to it. The client and staff behaviours in each second of each fragment were coded and a time-window data set was extracted that shows for each second in which a challenging behaviour was recorded, whether and how the staff member reacted in the following seconds.

Materials and methods

Procedure

Lambrechts *et al.* (2010) contacted 28 facilities in the Dutch speaking part of Belgium (i.e. Flanders) that are specialised in providing care for clients with severe (i.e. an IQ between 20 and 40 or a developmental age between 2 and 4 years) and/or profound (i.e. an IQ below 20 or a developmental age below 2 years) ID. Each facility was asked to film three clearly different situations (i.e. fragments) in which the client interacts with his/her usual staff member (which had worked with the client for at least 6

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Table 1 Duration (in seconds) of each selected fragment and number of encountered instances of challenging behaviour

	Fragment 1		Fragment 2		Fragment 3		Total	
Client	Duration (seconds)	# instances	Duration (seconds)	# instances	Duration (seconds)	# instances	Duration (seconds)	# instances
1	174	6	59	1	179	11	412	18
2	108	14	150	8	128	21	386	43
3	79	7	309	12	160	20	548	39
4	64	7	–*	–*	–*	–*	64	7
5	404	19	106	3	350	5	860	27
6	83	12	152	19	320	29	555	60
7	231	40	70	9	65	11	366	60
8	211	13	114	1	241	4	566	18
9	185	3	310	9	163	4	658	16
10	410	45	442	28	219	11	1071	84

* For the fourth client, only one fragment was selected.

months) and exhibits some of the challenging behaviours under study (i.e. aggressive/destructive, stereotyped and self-injurious behaviour). In order to make the setting as naturalistic as possible, the filming was done by another staff member that is known by the client.

Ten facilities agreed to participate in the study. Note that seven facilities are residential facilities, one facility is both residential and a day centre, one facility is residential and also a school, and one facility is a boarding school. Two facilities provided fragments for two dyads and the other eight facilities for a single dyad. Out of the recorded fragments, the authors selected fragments based on the following criteria (see also Lambrechts *et al.* 2010): (1) as many different situations as possible were selected for each dyad; (2) the fragments show a clear situation in which the staff member reacts to clients' challenging behaviour; and (3) the fragments were well-defined with a clear beginning and ending. Based on these criteria, all fragments of two dyads were removed because the challenging behaviour lasted for a long time, making it impossible to code discrete occurrences of this behaviour. Moreover, for one dyad only one fragment was selected because in the other fragments the staff member was not visible in the recording. Only two of the remaining 10 dyads belong to the same facility (i.e. dyad 1 and 2). The 28 fragments (i.e. nine dyads with three fragments and one dyad with one fragment) vary in duration between 84 and 442 seconds (see Table 1). The research design was reviewed and approved by the university's ethical commission.

Participants

The clients were between 12 and 48 years old. Six of them were male and four female. Four clients had a severe and six a profound ID (for more information regarding the clients and the staff, see table 1 of Lambrechts *et al.* 2010). The research was undertaken with the understanding and written consent of each staff member; also permission was asked to the client's parents or legal guardian.

Data collection

Instruments and coding of the data

Using the MediaCoder (Bos & Steenbeek 2008) software, Lambrechts *et al.* (2010) coded the (non)occurrence of challenging behaviour and associated staff reactions in each second of each fragment. Specifically, challenging behaviour was coded as (1) aggressive/destructive; (2) stereotyped behaviour; or (3) self-injurious behaviour. Moreover, it was coded which staff reactions out of a list of 15 (see Table 2) occurred; these 15 staff reactions pertain to the following five broad reaction categories, which were obtained from previous research

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(see Wilson *et al.* 1995; McConckey *et al.* 1999; Saloviita 2002; Jones & Hastings 2003; Bailey *et al.* 2006): (1) verbal staff reactions; (2) offering or taking away material/tasks; (3) seeking contact with the client; (4) stopping the challenging behaviour; and (5) maintaining distance from the client. Table 2 shows the adopted coding system. In Table 3, hypothetical original data from one fragment of a single client–staff member dyad are displayed, lasting 360 seconds (seconds in which no challenging behaviour or staff reaction occurs are omitted). The rows of Table 3 refer to the coded seconds and the columns to the three challenging behaviours and the 15 staff reactions.

Table 2 Coding system for challenging behaviours and staff reactions, which belong to five broad reaction categories

Challenging behaviour/staff reaction	Description
Challenging behaviours (CB) by the client	
Aggressive/destructive behaviour	Offensive actions or deliberate overt attacks directed towards other individuals or objects
Stereotyped behaviour	Voluntary acts that occur repeatedly and look unusual, strange or inappropriate to others
Self-injurious behaviour	Behaviour that causes damage to the person's own body
Staff reactions	
(1) Verbal behaviours	
Statement	The staff member makes a statement, e.g. 'What a beautiful day, today!'
Question	The staff member asks something, e.g. 'Did you sleep well?'
Encouragement	The staff member encourages the client, stimulates him or her to an activity, e.g. 'Come on!'
Giving order	The staff member gives a concrete order, e.g. 'Get up!'
Making a comment regarding stopping CB	All statements, comments, questions that refer to ending the CB, e.g. 'Please, stop with . . .', 'This is not intended', 'Will you finally stop. . .?'
(2) Stopping CB	
Physically stopping CB	The staff member stops the CB physically, e.g. stopping the client by holding his or her arms
Taking measures to stop CB	The staff member takes measures or makes changes in the environment to restrict CB, e.g. fixing the client, to put on a helmet or mitten, close the door
(3) Offering or taking away material/tasks	
Offering (alternative) material/task	The staff member offers material/a task that may (e.g. offering a sweater in a dressing situation) or may not belong to the ongoing activity/situation (e.g. stopping an activity to go for a walk)
Taking away material/task	The staff member takes away material or decides to stop the task, belonging to the ongoing activity/situation, e.g. taking away a jigsaw when one was trying to make the jigsaw
(4) Acts	
Act	The staff member performs an action belonging to the ongoing activity/situation, e.g. feeding in an eating situation, washing in a bathroom situation
Physical contact	The staff member has physical contact with the client, e.g. accompanying a client physically to another room
Gestures	The staff member expresses him/herself with gestures, e.g. doing a move with the hand to express that the client has to go to another room
(5) Maintaining distance	
Going to another room	The staff member goes to another room
Moving the client to another room	The client is moved to another room
Addressing oneself to another person/situation	The staff member addresses oneself to another person or another situation within the same room

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Extracting the time-window data set

To reveal how staff members react to challenging behaviour of clients, we performed a time-window analysis. In such an analysis, the staff reactions to a particular challenging behaviour of a client are studied within a pre-defined period of time (i.e. time-window). To this end, first, all seconds in which challenging behaviour occurs (i.e. instances of challenging behaviour), are extracted. Next, for each instance, the associated staff reactions are determined taking different time intervals into account. Specifically, we coded fast and delayed staff reactions, where fast responses occur at the challenging behaviour second or within the following 3 seconds and delayed responses occur between 4 and 6 seconds after the challenging behaviour second. Such a time-window approach is often adopted, because investigating the response at each second separately may yield an (too) irregular picture (e.g. Thompson *et al.* 2000; Munde *et al.* 2012). Moreover, to obtain a parsimonious descrip-

Table 3 Coded original data fragment for a single dyad

	Challenging behaviours			**Staff reactions**														
				Verbal					**Task**		**Contact**			**Stop**		**Distance**		
Time	**ag**	**se**	**si**	**sa**	**qu**	**en**	**go**	**mc**	**o**	**ta**	**ac**	**pc**	**ge**	**ps**	**tm**	**ga**	**mo**	**ad**
1	0	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
6	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
...																		
15	0	**1**	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
20	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
...																		
45	0	0	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	0	0	**1**	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
47	0	0	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
53	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
...																		
213	0	**1**	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
216	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
217	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
218	0	**1**	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
220	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
221	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
223	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
...																		
359	0	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
360	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0

'ag': aggressive/destructive behaviour; 'se': stereotyped behaviour; 'si': self-injurious behaviour; 'sa': statement; 'qu': question; 'en': encouragement; 'go': giving order; 'mc': making a comment regarding stopping the challenging behaviour; 'o': offering (alternative) material/task; 'ta': taking away material/task; 'ac': act; 'pc': physical contact; 'ge': gestures; 'ps': physically stopping the challenging behaviour; 'tm': taking measures to stop the challenging behaviour; 'ga': going to another room; 'mo': moving the client to another room; 'ad': addressing oneself to another person/situation.

Underlined seconds are instances of challenging behaviour that pertain to a row in Table 4. The occurrence of a challenging behaviour is indicated in bold.

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tion of the prototypical behaviour–response patterns, we focused on the five broader staff reaction categories. To this end, a reaction category was coded as present when one (or more) of the staff reactions belonging to that category was exhibited (within a period of 0–3 or 4–6 seconds).

To illustrate this time-window approach, we make use of Tables 3 and 4. Table 4 presents the time-window data set that is extracted from Table 3. For example, in Table 3, the first challenging behaviour occurs the first second. In the three subsequent seconds the staff member reacts with gestures (which belongs to the contact seeking reaction category), and in the fourth to sixth second with making comments to stop the challenging behaviour and giving orders, which both belong to the verbal reaction category. Therefore, in the first row of Table 4, this first instance of challenging behaviour is represented as stereotyped behaviour that is followed by a fast contact seeking response and a delayed verbal response.

When deriving the time-window data, we made the following choices. First, when in consecutive seconds the same challenging behaviour was exhibited, we only retained the last second of the sequence; staff reaction categories that were encountered in the deleted seconds of the sequence, were counted as fast responses. For example, the self-injurious behaviour sequence at seconds 45–47 in Table 3, is presented as a single challenging behaviour instance in Table 4 (i.e. instance 3 which pertains to second 47), with the fast response reflecting the reaction categories in seconds 45–50, and the delayed response reflecting seconds 51–53. Note, however, that staff responses only seldom occurred in the deleted sequence seconds (i.e. seconds 45 and 46) and, if they occurred, the decision on whether or not to code them, did in most cases not change the obtained time-window data, because the staff reaction was repeated later on. For example, the decision on whether or not the (fast) verbal behaviour in second 46 is taken into account, has no repercussions for the time-window data as a (fast) verbal reaction was also encountered at second 49. Second, when two challenging behaviours of the same type were less than 7 seconds apart (but not in a sequence), they were considered as two separate instances of challenging behaviours. If challenging behaviours of different types were

Table 4 Hypothetical time-window data derived from the original data in Table 3

	Challenging behaviours			Fast staff reactions				Delayed staff reactions			
	Aggressive	Stereotyped	Self-injurious	Verbal	Task	Contact	Stop	Distance	Verbal	Task	Contact	Stop	Distance
Instance 1	0	1	0	0	0	1	0	0	1	0	0	0	0
Instance 2	0	1	0	0	0	1	0	0	1	0	0	0	0
Instance 3	0	0	1	1	0	0	1	0	1	0	0	0	0
Instance 4	0	1	0	1	0	0	1	0	0	0	1	0	0
Instance 5	0	1	0	1	0	1	1	0	1	0	1	0	0

A score of 1 (0) indicates that the associated challenging behaviour/staff reaction is present (absent) for the instance in question.
The challenging behaviours are 'aggressive': aggressive/destructive behaviour; 'stereotyped': stereotyped behaviour; 'self-injurious': self-injurious behaviour. The (fast and delayed) staff reactions are 'verbal': verbal staff reactions; 'task': offering or taking away material/task; 'contact': seeking contact with client; 'stop': stopping the behaviour; 'distance': maintaining distance from client.

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encountered within a 6-second period, which happened rarely only, staff reactions for which it is not clear whether they pertain to the first or the second behaviour (because they occur at or after the second instance) were assigned to the second instance. Third, when a challenging behaviour occurred within the last 6 seconds of a fragment, rendering an adequate registration of fast and delayed staff reactions impossible, we removed this instance of challenging behaviour from the analysis. For example, Table 4 contains no data pertaining to the stereotyped behaviour at second 359 of Table 3.

As a result, we obtained for each dyad a binary time-window data matrix with the rows referring to the extracted challenging behaviour instances and the columns to the three challenging behaviours, the five fast staff reaction categories, and the five delayed staff reaction categories. The entries of this matrix indicate for each instance which of the three challenging behaviour types was displayed by the client under study and which categories of staff reactions were encountered. In Table 1, for each dyad, the number of challenging behaviour instances are presented for each fragment separately.

Analysis of the time-window data by means of Clusterwise HICLAS

To capture interdyad differences and similarities in behaviour–reaction patterns, we performed a Clusterwise HICLAS analysis (Wilderjans *et al.* 2012a) to the time-window data. To introduce Clusterwise HICLAS, which generalises the HICLAS (De Boeck & Rosenberg 1988) model for a single binary data matrix (e.g. time-window data for a single dyad) to multiple binary data matrices regarding the same variables (e.g. time-window data for multiple dyads), we first recapitulate HICLAS using the hypothetical time-window data in Table 4.

HICLAS

Applying HICLAS to our time-window data unravels the prototypical *if* challenging behaviour *then* staff reaction rules that appear systematically in the data of this dyad. Table 4 shows three prototypical patterns: (1) some stereotyped behaviour elicits a fast contact seeking response and a delayed verbal reaction (i.e. instance 1 and 2); (2) other stereotyped behaviour triggers fast verbal and stopping reactions and delayed contact seeking (i.e. instance 4); and (3) some self-injurious behaviour is associated with fast and delayed verbal reactions and a fast stopping reaction (i.e. instance 3). Note that for the dyad under study two prototypical patterns (i.e. pattern 1 and 2) involve stereotyped behaviour. The staff reactions to this behaviour, however, differ considerably between both patterns. This may imply that the staff member distinguishes different variants or functionalities of stereotyped behaviour (because of contextual factors or more refined features of the behaviour) and reacts accordingly (e.g. stopping the stereotyped behaviour is more important when the behaviour is harmful for the client than when the stereotyped behaviour is less detrimental). Instances of stereotyped behaviour that have features of both variants (i.e. instance 5) will therefore elicit all reactions of patterns 1 and 2.

Besides disclosing the prototypical patterns, HICLAS also sheds light on the incidence (i.e. how often they are encountered) of the prototypical patterns and their combinations for the dyad in question. In our example (see Table 4), the first pattern occurs twice, whereas the second and third and the combination of the first and the second are only encountered once.

The hypothetical data in Table 4 can be perfectly fit (i.e. all zeros and ones can be predicted correctly) by a HICLAS model with three prototypical patterns. In practice, however, data sets are much larger and will always contain noise (i.e. some zeros should actually have been a one and vice versa). As a consequence, the underlying prototypical patterns cannot be easily unravelled by visual inspection only (e.g. simply listing the most frequently occurring patterns). Indeed, because of noise, different observed data patterns may actually be instantiations of the same prototypical pattern. Therefore, clustering the binary data patterns, HICLAS infers a low number of prototypical patterns that fit or explain the data well, which is reflected in a low percentage of mispredictions (for an example in which HICLAS was successfully used to reveal underlying idiographic patterns of behavioural and emotional reactions to situational events, see Claes *et al.* 2004).

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Often the number of prototypical patterns is not known beforehand. Similarly to the scree and eigenvalue-greater-than-one procedures in common factor analysis, researchers can deal with this uncertainty by fitting HICLAS models with different numbers of patterns. Subsequently, one applies a model selection heuristic to the obtained solutions to pick a model that describes the data well (i.e. high percentage of correctly predicted data entries), without being overly complex (i.e. low number of prototypical patterns). HICLAS variants of the well-known scree test have been presented by Ceulemans and colleagues (Ceulemans *et al.* 2003; Ceulemans & Van Mechelen 2005; Wilderjans *et al.* 2008, 2012b). Note that HICLAS is a deterministic clustering technique in that no explicit distributional assumptions are made, regarding, for instance, the noise (i.e. prediction errors) in the data. As a consequence, HICLAS provides no significance tests and information criteria (Akaike Information Criterion, Akaike 1974; Bayesian Information Criterion, Schwarz 1978) that were developed for model selection among stochastic models (i.e. models that include a number of distributional assumptions) cannot be used. Moreover, many model selection methods that have been proposed for other deterministic clustering techniques like *K*-means (Steinley & Brusco 2011) cannot be readily extended to the HICLAS case, because of its binary nature.

Clusterwise HICLAS

In the Clusterwise HICLAS analysis, the time-window data of all dyads are analysed simultaneously. The goal of the analysis is to cluster the dyads based on their prototypical behaviour–reaction patterns that are induced from the data. Stated differently, dyads with similar prototypical patterns are clustered together, whereas dyads with different patterns are assigned to different clusters. Herewith, the incidence of the cluster-specific prototypical patterns may differ among the dyads within a cluster. As Clusterwise HICLAS essentially yields two clusterings, one of the dyads and one of the behaviour–reaction patterns in each dyad cluster, this method parsimoniously reveals interdyad differences and similarities (i.e. clustering of the dyads) in prototypical behaviour–reaction patterns (i.e. clustering of the patterns).

Clusterwise HICLAS has some clear benefits over other possible methods to analyse the time-window data. A first possibility is to apply a latent class analysis to the data. However, such an analysis would only cluster the behaviour–reaction patterns directly and not the dyads, making it more difficult to capture the interdyad differences in these patterns. Indeed, the cluster-specific HICLAS analyses reveal the patterns that consistently occur within each cluster (and not across clusters, although some of the patterns may appear in multiple clusters). A second option would be to simply list the patterns that are encountered most often in the time-window data. This solution suffers from the same problem as the first option, in that it does not yield a direct clustering of the dyads. Another limitation of this solution is that it cannot easily handle the noise in the data (see *HICLAS* subsection). Finally, one could for each combination of a challenging behaviour and a staff reaction compute an odds ratio for the whole data set or for each dyad separately. Also this procedure would not immediately cluster the dyads, making it difficult to grasp the interdyad differences and similarities (i.e. studying the differences and similarities between 10 sets of odds ratios is much harder than interpreting the cluster-specific prototypical patterns derived from a Clusterwise HICLAS analysis).

Model selection for Clusterwise HICLAS

When applying Clusterwise HICLAS, both the number of dyad clusters and the number of prototypical patterns per cluster has to be assessed, as they are usually not known beforehand. To this end, different Clusterwise HICLAS analyses with increasing numbers of clusters and prototypical patterns are performed and a final model is determined by adopting a sequential scree procedure in which, first, the number of clusters is determined, and, next, based on the chosen number of clusters, the number of prototypical patterns (an equivalent sequential procedure for a similar model selection problem is adopted in De Roover *et al.* 2012; Wilderjans & Ceulemans in press). To select the optimal number of clusters, an automated scree test is applied for each number of patterns separately. This scree test determines which solution is optimal in that lowering the complexity (i.e. lower number

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of clusters) yields a serious decrease in model fit, whereas increasing the complexity improves the fit only slightly; in other words, it looks for a solution that balances model fit and model complexity. Specifically, one selects the number of clusters i that maximises the scree ratio $r_i = \frac{f_{i-1} - f_i}{f_i - f_{i+1}}$, with f_i denoting the percentage of mispredictions for the solution with i clusters and the number of patterns under study. The number of clusters is then chosen by majority vote, that is, it equals the number of clusters that is selected most often across the different numbers of patterns. Next, given the chosen number of clusters, the same automated scree test is applied to determine the number of prototypical patterns. To this end, again, the ratio $r_i = \frac{f_{i-1} - f_i}{f_i - f_{i+1}}$ is maximised, with f_i now being the percentage of mispredictions for the solution with i patterns and the selected number of clusters (for more information on model selection heuristics that may be used within HICLAS models, see Ceulemans & Van Mechelen 2005; Wilderjans *et al.* 2008, 2009, 2013).

Table 5 Number (and percentage) of instances of challenging behaviours and number (and percentage) of associated staff reactions for the time-window data set of Lambrechts *et al.* (2010)

Challenging behaviour/staff reaction	*n*	Percentage
Challenging behaviours	372	
Aggressive/destructive behaviour	133	35.75*
Stereotyped behaviour	59	15.86
Self-injurious behaviour	180	48.39
Staff reactions	904	
Fast staff reactions	511	56.53†
Verbal staff reactions	169	18.69†
Offering or taking away material/task	13	1.44
Seeking contact with client	157	17.37
Stopping the behaviour	156	17.26
Maintaining distance from client	16	1.77
Delayed staff reactions	393	43.47
Verbal staff reactions	151	16.70
Offering or taking away material/task	5	0.55
Seeking contact with client	128	14.16
Stopping the behaviour	95	10.51
Maintaining distance from client	14	1.55

* Percentage of challenging behaviours (of the associated type).
† Percentage of staff reactions.

Results

Inter-rater reliability of the coding of the original observational data

To determine the inter-rater reliability, Lambrechts *et al.* (2010) randomly selected about 20% of the filmed seconds across all clients and fragments and asked a second observer to independently code these seconds. Next, the authors computed the kappa coefficient (Cohen 1960) between the codes of both observers, taking a margin of 5 and 10 seconds into account, because of the continuous sampling (Jansen *et al.* 2003). It turned out that the inter-rater agreement equals 0.69 and 0.73 for a tolerance level of 5 and 10 seconds, respectively, which can be conceived as a substantial (Landis & Koch 1977) to moderate (Shrout 1998) level of inter-rater agreement.

Incidence of challenging behaviours and staff reactions in the time-window data

Regarding the incidence of the different challenging behaviours, Table 5 shows that self-injurious and aggressive/destructive behaviour occurred rather frequently in the time-window data (i.e. 180 and 133 out of the 372 instances of challenging behaviour respectively), whereas stereotyped behaviour is displayed less often. Regarding staff reactions, verbal reactions, contact seeking and stopping the challenging behaviour occurred regularly, whereas offering/taking away materials/tasks and maintaining distance were seldom observed. Moreover, for each staff reaction category more fast responses were encountered than delayed ones (i.e. 511 of the 904 staff reactions were fast reactions), with the difference being largest for stopping reactions (see Table 5).

Selection and interpretation of the Clusterwise HICLAS solution

Model selection

We performed Clusterwise HICLAS analyses with the number of clusters and prototypical patterns ranging from one to four. Figure 1 presents the percentage of mispredictions for each obtained

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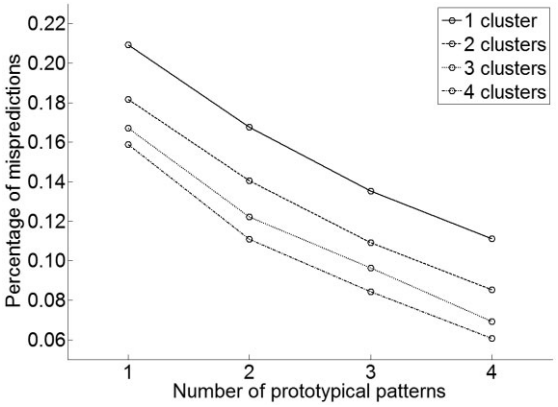


Figure 1 Percentage of mispredictions of the Clusterwise Hierarchical Classes Analysis (HICLAS) solutions for the time-window data with the number of clusters and the number of prototypical patterns ranging from one to four.

solution. First, we assessed the number of clusters: When conducting per number of patterns, a separate scree test for the number of clusters, twice a two-cluster solution and twice a three-cluster solution is selected. In particular, when considering the solutions with one pattern and with three patterns separately, the two-cluster solution was selected, whereas among the solutions with two and with four patterns, a three-cluster solution was retained. Therefore, to decide on the number of clusters, we inspected the scree lines of the two and three-cluster solutions. While the scree line for the three-cluster solutions (red line in Fig. 1) shows an elbow at the solution with two patterns, no elbow can be found in the scree line for the two-cluster solutions (green line). In particular, when only considering the solutions with three clusters, the r_i-value (see *Model selection for Clusterwise HICLAS* subsection) for the two-component/pattern solution (i.e. 1.7360) is clearly larger than the r_i-value for the three-component solution (i.e. 0.9542), implying a (relatively) sharper increase in model fit when going from one to two components compared with when going from two to three components (although the corresponding elbow is not so easily discerned in Fig. 1). For the two-cluster solutions, the r_i-values for the two- and three-component solutions are almost identical (i.e. 1.3026 and 1.3103), implying that the two-cluster scree line shows no clear elbow. As such, we retained the solution with three clusters and two prototypical patterns, as it adequately balances model (mis)fit (i.e. percentage of mispredictions) and model complexity (i.e. number of clusters and patterns). Indeed, as one can see in Fig. 1, discarding one cluster and/or one prototypical pattern (i.e. lowering the complexity) results in a considerable increase in the percentage of mispredictions (i.e. decrease in model fit), whereas adding a cluster and/or pattern hardly decreases the percentage of mispredictions. The selected solution mispredicts only 591 out of the 4836 entries (i.e. 12.22%), resulting in 87.78% of the observed data patterns being explained by the prototypical patterns.

Interpretation

In Table 6, the Clusterwise HICLAS solution with three clusters and two prototypical patterns for each dyad cluster is displayed. Some of the staff reaction categories (i.e. offering or taking away material/task and maintaining distance) never show up in the prototypical patterns (and are therefore not mentioned in Table 6), which is not a surprise as they occur very rarely in the time-window data (see Table 5). Table 7 shows, for each dyad, the percentage of instances for which each cluster-specific prototypical pattern (or their combination) is encountered.

The first cluster is an idiosyncratic one in that it only subsumes one dyad. Hence, the behaviour–response patterns that are typical for this dyad clearly differ from the prototypical patterns of the other dyads. The client of this dyad regularly shows stereotyped behaviour, to which the staff member reacts in two possible ways: (1) a fast reaction in which the staff member tries to stop the behaviour and reacts verbally; and (2) a fast and delayed stopping reaction, and a delayed verbal response. Note that also the combination of both prototypical patterns is encountered.

The second cluster consists of two dyads of which the clients only exhibit self-injurious behaviour. The typical staff reactions to this behaviour are, on the one hand, trying to stop the behaviour (fast and delayed), and, on the other hand, quickly seeking contact with the client. In Table 7, one can see that for the seventh dyad the first pattern was

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Table 6 Clusterwise Hierarchical Classes Analysis (HICLAS) solution with three clusters and two prototypical patterns for the time-window data

	Challenging behaviours			Fast staff reactions			Delayed staff reactions		
	Aggressive	**Stereotyped**	**Self-injurious**	**Verbal**	**Contact**	**Stop**	**Verbal**	**Contact**	**Stop**
Cluster 1 (1 dyad)									
Pattern 1	0	1	0	1	0	1	0	0	0
Pattern 2	0	1	0	0	0	1	1	0	1
Cluster 2 (2 dyads)									
Pattern 1	0	0	1	0	0	1	0	0	1
Pattern 2	0	0	1	0	1	0	0	0	0
Cluster 3 (7 dyads)									
Pattern 1	0	0	1	1	1	0	1	1	0
Pattern 2	1	0	0	1	0	0	1	0	0

The reaction categories maintaining distance and offering or taking away material/task are not included in the table because they did not show up in the prototypical patterns.
Challenging behaviours are 'aggressive': aggressive/destructive behaviour; 'stereotyped': stereotyped behaviour; 'self-injurious': self-injurious behaviour. Staff reactions are 'verbal': verbal staff reactions; 'contact': seeking contact with client; 'stop': stopping the behaviour.

Table 7 Percentage of challenging behaviour instances in which one or both of the two prototypical patterns, which are presented in Table 6, show up for each dyad

	Pattern 1 (%)	**Pattern 2 (%)**	**Pattern 1 and 2 (%)**
Cluster 1			
Dyad 3 (39 instances)	51	31	15
Cluster 2			
Dyad 7 (60 instances)	55	10	3
Dyad 10 (84 instances)	21	57	12
Cluster 3			
Dyad 1 (18 instances)	0	78	0
Dyad 2 (43 instances)	0	42	14
Dyad 4 (7 instances)	14	57	0
Dyad 5 (27 instances)	4	44	0
Dyad 6 (60 instances)	48	23	18
Dyad 8 (18 instances)	0	83	0
Dyad 9 (16 instances)	0	25	0

encountered the most and for the tenth dyad the second pattern, whereas the combination of both patterns occurred rarely.

The majority of the dyads belongs to the third cluster which is characterised by the following two patterns: (1) self-injurious behaviour which goes along with fast and delayed verbal reactions and seeking contact; and (2) aggressive behaviour that elicits a fast and delayed verbal response. As these patterns hold for seven of the 10 dyads and self-injurious and aggressive behaviour are the most prevalent challenging behaviours in the data (see Table 5), it can be concluded that these patterns are probably dominant in clinical practice. For most dyads, the second pattern has a larger incidence than the first pattern, whereas the reverse is true for the sixth dyad (see Table 7).

Discussion

Interdyad differences in challenging behaviour–staff reaction patterns

The goal of this study was to demonstrate that Clusterwise HICLAS is a useful method for revealing interdyad differences and similarities in client behaviour–staff response patterns. Indeed, applying Clusterwise HICLAS to the data of Lambrechts *et al.* (2010), disclosed clear differences among clients in the type of challenging behaviour they display: Whereas we found two dyad clusters that comprise clients that only exhibit stereotyped and self-injurious behaviour, clients in the third dyad cluster switch between aggressive and self-injurious behaviour. Moreover, interdyad differences in how staff members

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respond to particular challenging behaviour were found: The staff member of the third dyad cluster reacts verbally to self-injurious behaviour and seeks contact, whereas the staff members that belong to the second cluster seek contact and try to stop the self-injurious behaviour. These findings clearly complement and qualify the group-level results of Lambrechts *et al.* (2010), who report that self-injurious behaviour elicits verbal responses, stopping behaviour and contact seeking.

Three factors may explain the interdyad differences in the reactions to self-injurious behaviour. A first factor may be the severity of this behaviour. Dyads in the second cluster might display more or stronger self-injurious behaviour than dyads in the third cluster, which would make stopping the challenging behaviour more important for the second cluster. A second factor may be that a particular challenging behaviour has a different functionality across clients (Borthwick-Duffy 1994), which of course qualifies the effectiveness of staff reactions. A third factor may be that some of the verbal reactions could be considered stopping behaviour also as they involve verbal comments of the staff that are aimed at ending the challenging behaviour. Therefore, it may be conjectured that also in the third cluster, direct support workers try to stop the self-injurious behaviour, but in a verbal way.

A remarkable finding is that the staff typically reacts to stereotyped behaviour by trying to stop the behaviour. In the literature a debate is going on about whether or not staff should try to stop stereotyped behaviour, because such behaviour may have its own functionality for the client in question, without resulting in much damage and/or limiting the clients' functioning. This finding, however, should be interpreted with caution, as it pertains to one dyad only.

Limitations of the study

Although using a naturalistic set-up has many advantages, there are also some limitations (Lerman & Iwata 1993). First, no causal conclusions regarding the relationships between challenging behaviour and staff reactions are permitted (Bijou *et al.* 1968). Second, our sample consisted of 10 dyads only, which were selected because the clients were known for their challenging behaviour in particular situations. Therefore, our results cannot be readily generalised to all clients with severe or profound ID.

Another point of discussion pertains to how fast and delayed responses were defined. Indeed, defining a fast response as a response occurring within the first 3 seconds and a delayed response as a response that was encountered after 4–6 seconds is somewhat arbitrary. One could, for instance, also consider blocks of 5 seconds (i.e. within the first 5 seconds is a fast response and a response within 6–10 seconds is a delayed response) or make a more fine-grained distinction (i.e. fast, delayed and late response).

A final limitation of the study is that the 10 dyads came from nine different service facilities and involved 10 different clients and staff members. As such, it is impossible to disentangle interfacility differences from interclient and interstaff differences.

Challenges for further research and clinical implications

In this paper, no attempt was made to analyse the processes underlying the observed behaviour–reaction patterns and the individual differences therein, because the data did not contain the necessary information. Indeed, to account for the relations between challenging behaviours and staff reactions one might include possible mediating variables such as cognitions (e.g. what is the functionality of a specific challenging behaviour), emotions (e.g. does the staff member feel safe when interacting with the client), staff well-being (e.g. stress), attitudes to helping behaviour, etc. (Rose *et al.* 1998; Hastings 2005; Lambrechts *et al.* 2008, 2009; Willner & Smith 2008). To this end, one may resort to a specific type of HICLAS models, called classification models for the study of sequential processes and individual differences therein (CLASSI, Ceulemans & Van Mechelen 2008; Ceulemans *et al.* 2012; Vande Gaer *et al.* 2012).

Disclosing individual differences between clients and direct support workers may be very relevant in clinical practice, in order to suggest particular training programmes to direct support workers and to help the staff to optimally deal with specific clients. To this end, service facilities may collect behaviour–reaction data themselves and analyse these data with

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Clusterwise HICLAS (software for running this analysis can be obtained from the first author). In case only data from a single dyad are available, a HICLAS analysis (De Boeck & Rosenberg 1988) may be used to unravel the prototypical patterns of this dyad. When staff members do not have the time to film and code fragments of situations with challenging behaviours, information may also be collected on the basis of questionnaires (for an example in clinical psychology in which HICLAS is used to disclose prototypical situation–reaction patterns given questionnaire data, see Claes *et al.* 2004).

Conclusion

Clusterwise HICLAS can be used to complement and qualify the general behaviour–response patterns that are revealed by a group-level analysis, because this method enables the researcher to identify the interdyad differences and similarities in these patterns. As such, Clusterwise HICLAS may stimulate the development of client-centred support practices that are more focused on the specific abilities (instead of disabilities) of each client and that take into account the specific functionality that the challenging behaviour may have for the individual client (Nakken & Vlaskamp 2007).

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