# Developing an integrated biomedical and behavioural theory of functioning and disability

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**Abstract**

**The International Classification of Functioning Disability and Health (ICF) offers an agreed language on which a scientific model of functional outcomes can be built. The ICF defines functional outcomes as activity and activity limitations (AL) and defines both in behavioural terms. The ICF, therefore, appears to invite explanations of AL as behaviours.**

**Studies of AL find that psychological variables, especially perceptions of control, add to biomedical variables in predicting AL. Therefore two improved models are proposed, which integrate the ICF with two psychological theories, the Theory of Planned Behaviour (TPB) and Social Cognitive Theory (SCT). These models have a sound evidence base as good predictors of behaviour, include perceived control constructs and are compatible with existing evidence about AL.**

**When directly tested in studies of community and clinic-based populations, both integrated models (ICF/TPB and ICF/SCT) outperform each of the three basic models (ICF, TPB and SCT). However, when predicting activity rather than AL, the biomedical model of the ICF does not improve prediction of activity by TPB and SCT on their own.**

**It is concluded that these models offer a better explanation of functional outcomes than the ICF alone and could form the basis for the development of improved models.**

**Key words**

**ICF, disability, theory, TPB, social cognitive theory**

## Introduction

Health conditions lead to changes in individual functioning; the health states achieved by elite athletes result in enhanced performance while diseases result in limitations. The aim of this paper is to establish a rationale for integrating behavioural theory with the main biomedical theory to develop improved models of functioning and disability. We argue that separate development and testing of psychological models in isolation from biomedical theory or testing biomedical models without integrating behavioural theory may result in parallel explanations and fail to capitalise on the gains in explanatory power that are possible by considering both types of models together.

### *Biomedical theory of functioning and disability*

Many health conditions result in a diminution of functioning. The ICF (WHO, 2001) proposes a framework for investigating functioning and disability in 'all people', including the elite athlete, the person recovering from a health condition, and the person with severe disabilities. It has achieved considerable international consensus in clarifying the language to describe function and in classifying function in a comprehensive and acceptable manner. This language and classification offers a foundation for building shared understanding of the processes associated with loss of function and a cumulative scientific approach to functioning and disability

The ICF proposes three health components to describe function: body structure and function (BS&BF); activity (A) and participation (PR).Each of the three function components may be diminished by health conditions including disease, disorder or injury but also conditions such as pregnancy or old age. Then the components are described as impairment (I), activity limitations (AL) and participation restrictions (PR) respectively (see Figure 1 for models and definitions). The loss of function is described as disability. However a continuum from high functioning to severe disability is envisaged. Additionally, the health components can influence each other, so that impairment of body structure may be the factor that results in AL. Functioning and disability are also influenced by context, including personal and environmental factors e.g. when loss of income results in lack of access to a swimming pool and subsequent reduction in swimming ability.

Insert figure 1 about here (containing both ICF and ICICH)

The WHO ICF framework has been widely welcomed primarily for providing a common, shared language (Jette, 2006, 2009 a, b), an important feature in a context where previously different words were used for the same theoretical construct and the same word was used for different constructs, e.g. the word ‘disability’ in the ICIDH translates to ‘functional limitations’ in Nagi’s model (Nagi, 1965), while the latter used the word ‘disability’ to refer to what the ICIDH labels ‘handicap’; this resulted in confusion in measurement of constructs (Pollard & Johnston, 2001; Pollard, Johnston, & Dieppe, 2006; Johnson & Wolinsky, 1993).

The ICF has been referred to as “a new way for the world to talk about health’ (Bruyere & Peterson, 2005) and it has been successfully adopted in many areas of clinical practice and research (Bruyere, Van Looy, & Peterson, 2005). The main criticisms of the ICF centre round the problem of discriminating the A and P constructs ~~(Jette, Haley, & Kooyoomjian, 2003; Jette, Tao, & Haley, 2007)~~ and the lack of specification of relationships between the constructs. While several authors (e.g.Jette, Haley, & Kooyoomjian, 2003; Jette, Tao, & Haley, 2007) have noted the conceptual difficulties in discriminating between A and P, studies using Discriminant Content Validity methods have shown that judges can clearly identify items that discriminate between A and P (Dixon, Pollard & Johnston,2007; Dixon, Johnston, McQueen & Court-Brown, 2008) and both qualitative(Dixon & Johnston, 2008) and quantitative (Pollard, Dixon, Dieppe,& Johnston, M., 2009) studies show that people with disabilities can separate these constructs. Unlike the earlier WHO (1980) model, the ICIDH (Figure 1), the ICF is not intended as a full causal process model; it 'does not model the "process" of functioning and disability. It provides the building blocks for users who wish to create models and study different aspects of this process.' (p18) (Imrie, 2004).

***The need for, and advantages of, a causal model***

The advantage of a causal process model, rather than simply the identification of relevant constructs, is that it can summarise what is known about how constructs relate to each other. A successful model makes implicit assumptions explicit and testable; it offers an explanation, suggests new and testable hypotheses and can be tested against alternative hypotheses. A model of AL should describe the factors that influence the development and variability of AL. In addition to the scientific value, such a model might also be useful in a clinical situation, for example, in understanding factors leading one patient to be more disabled than another or in explaining why someone with an unchanging medical condition might be more disabled one day than another. A causal model additionally presents hypotheses about how one construct acts to cause another and describes the chain or combination of events likely to lead to changes in a target construct (Hardeman, Sutton, Griffin, Johnston, White, Wareham et al.,, 2005) and is an essential basis for the development of interventions to improve patient outcomes. For example, a simple medical model suggests that disability will only be reduced by curing the causal medical condition; whereas the ICF framework suggests that contextual factors might be influential and therefore offer opportunities for intervention.

The most prominent alternative to the ICF approach, and one which incorporates a causal model, is the disablement model of Nagi (Nagi, 1965), and variations or developments of this model (Verbrugge & Jette, 1994). Jette, who had previously been a proponent of the Nagi model, has proposed adoption of the ICF framework in the interests of more effective communication between scientists and clinicians and because the two models have very similar components ( Jette, 2009a). Others are less persuaded and are concerned about losing features of the Nagi model, especially the hypothesised causal disablement process and the social context (Guralnik & Ferrucci, 2009). The processes proposed by Nagi are similar to the process in the ICIDH whereby disease causes impairment which in turn may cause functional limitations and resulting social disadvantage. However neither of these models addressed 'functioning' (as against disability) except in the implicit assumption that functioning would not be limited without disease/disorder or impairment. They do not address variations of function within unimpaired populations. Nor do they adequately explain why two individuals with similar disease and impairment, in identical social environments, might have very different levels of activity. Importantly, they do not give an adequate account of factors influencing recovery (from impairment, activity limitations and participation restrictions) nor do they give sufficient attention to the behavioural processes involved.

Freedman (2009) has proposed that the ICF be modified to take account of 'accommodations' or 'behavioral responses to changes in capacity' (p 1173) that moderate the effects of impairment on AL and PR. These behavioural responses include making modifications to the environment or behaving differently, e.g. doing less or more slowly. Thus, based on his observations, Freedman is proposing that the ICF progress to a causal model incorporating novel constructs (Freedman, 2009).

Despite asserting that it does not model causal processes, the ICF is an attempt to provide a conceptual model that can integrate two contrasting models: the biomedical model (where limitations are directly caused by health conditions and reversed by medical treatment and management) and the social model (where limitations are created by the social environment and reversed by social and political change). It attempts to synthesise biological and social perspectives in a biopsychosocial model. While it has elaborated the 'bio' and 'social' elements, the 'psycho' aspect is largely lacking except for reference in the personal contextual factors to '...lifestyle, habits, coping styles, past and current experiences,…overall behaviour pattern and character style, individual psychological assets and other characteristics…'(p17) (WHO, 2001). Nevertheless several studies have tried to operationalise the psychological aspects (Geyh, Peter, Mueller, Bickenbach, Kostanjsek, Uestuen et al., 2011).

In identifying the need for behavioural factors in modelling the process of functioning and disability, both the ICF and Freedman (2009) recognise a role for psychological factors but make very little use of theories, evidence and methods from behavioural and psychological science. A more efficient, and probably more successful, approach would be to integrate what has already been established in behavioural science with the ICF. Here we attempt this integration in theorising factors that influence A and AL. We recognise that this is only attempting to develop an explanatory model for one part of disability as conceptualised in the ICF. The models presented here lack full integration of the ICF as they do not include the participation (restrictions) construct. However, the participation and participation restrictions aspects of the model are less well developed, and additional work is needed before including them in a theoretical model (Seekins, Ipsen, & Arnold, 2007).

Further, our focus is limited to the elaboration of the biomedical pathway (i.e. the impact of I on AL) rather than the reverse pathways which might explain how AL impacts I. Thus the causal model proposed to explain AL from the ICF is similar to that proposed by the ICIDH and, incorporates a commonly accepted model in which understanding bodily impairments determines daily functioning and that interventions to reduce impairments translate into improved daily functioning (Reed, Lux, Bufka, Trask, Peterson, Stark et al., 2005). Research with patients prior to joint replacement surgery confirmed that their personal causal model of their condition and its treatment conformed to the model of I influencing AL, which in turn influenced PR (Pollard, Dixon, Johnston, in press).

***Integrating behavioural and psychological science with the ICF to explain A and AL: Disability as behaviour***

A key reason for integrating behavioural science with the ICF is that A and AL are defined in terms of behaviour. For example, the activity of walking is a behaviour and is also used as an indicator of locomotor activity limitations. The earlier WHO model, the ICIDH, gave a prominent role to behaviour in defining disability in terms of the performance of activities but conceptualised it as a consequence of disease. Nevertheless, by defining disability in terms of behaviour, it invited behavioural explanations of discrepancies between observed disability and the level of disability that might have been expected from the observed impairments. Evidence from research associated with the Nagi model demonstrates support for a biomedical model by finding that impairment predicts AL (Verbrugge & Jette, 1994). However this is not always found: for example, the extent of joint degeneration in osteoarthritis predicted neither symptom reporting nor physical function (Salaffi, Cavalieri, Nolli, & Ferraccioli, 1991; Summers, Haley, Reveille, & Alarcon, 1988), similarly, neurological and cardiac impairment did not predict recovery from disability in stroke and MI patients (Johnston & Pollard, 2001). Even where impairment does predict AL, there continues to be unexplained variance in the observed activity levels. Therefore there is a need for predictors of the behaviour, observed as AL, that go beyond disease or impairment and include other determinants of behaviour.

Conceptualising disability as defined by the ICIDH, (or AL in ICF terms), as ‘behaviour’ (Johnston, 1994, 1996; Johnston, Bonetti, & Pollard, 2002; Van der Ploeg, Hidde, Allard, Van der Woude, Luc & Van Michelen (2004) ) allows the incorporation of causal factors, in addition to disease/disorder and impairment, in explaining A and AL. We, like others, consistently find that theorised psychological variables add to disease and impairment measures in predicting AL (see later section for evidence). The ICF defines A and AL in terms of behaviour or activities, without mention of impairment as a necessary defining feature and recognises a role for behavioural influences under the headings of Personal and Environmental Context.

Therefore adequate explanation of the processes involved in A or AL requires specification of factors that influence behaviour. Psychology investigates why people do things and how their behaviour is changed and is commonly defined as 'the science of behaviour'[1]. The choice of postulated influences may be derived from evidence of isolated psychological factors in studies of AL or from fully developed psychological theory. While the former approach immediately identifies likely influences on AL, it loses the accumulation of scientific knowledge about behaviour. Theories not only specify possible influences on behaviour, they postulate other co-acting influences, the relationships between them and the processes involved. Further, good theories are based on large accumulations of evidence and tests of assumptions. Any intervention to improve health outcomes requires a hypothesis about the underlying causal influences; where theory has not been specified, these hypotheses have simply not been made explicit and implicit theories remain untestable. Therefore, in order to gain the advantages of both behavioural and biomedical approaches, it is proposed to progress from evidence of factors associated with AL to theoretical models which incorporate these factors and to integrate these models with the ICF.

***Psychological Theory that might integrate with the ICF***

The publication and widespread acceptance of the ICF allows the possibility of fully integrating psychological models with the bio-social model offered by the ICF. Just as medical and social models have in the past run on parallel or competing tracks, psychological and biological models of AL have tended to operate in separate universes. Some decades ago,

[1] **American Psychological Association:** 'Psychology is the study of the mind and behavior. The discipline embraces all aspects of the human experience — from the functions of the brain to the actions of nations, from child development to care for the aged.' http://www.apa.org/support/about/apa/psychology.aspx#answer 15.11.2010

psychological models were most frequently invoked when there was no adequate biological explanation for AL and psychological 'disorder' was sought as an explanation. More recently, psychological approaches to predicting and explaining AL have not been restricted to disordered psychological functioning, but propose explanations in terms of cognitions and emotion.

Some psychological models, or theoretical constructs, have been applied directly to explain activity limitations in people with disease/disorder or impairment, including models of emotional factors such as catastrophising or fear-avoidance (Lethem, Slade, Troup, Bentley 1983; Vlaeyan & Linton, 2000; Leeuw, Goossens,, Linton, Crombez, Boersma, & Vlaeyen, 2007.), or personality theory ( e.g. Krueger, Wilson, Shah, Tang and Bennett, 2006; White, Driver& Warren 2008) or cognitive models, especially the construct of self-efficacy from Social Cognitive Theory (Lorig & Holman, 2003)

These 'psycho' approaches are not fully integrated with 'bio' and 'social' models; instead they mainly appear as a parallel research literature. While the biomedical literature explains AL in terms of health conditions and impairments, the more psychological literature identifies psychological constructs which predict AL. Unless both biomedical and behavioural constructs are presented in the same models or at least tested empirically at the same time, they may simply be alternative accounts of the same phenomena rather than offering a cumulative understanding of AL. So, for example, biomedical explanations in terms of musculoskeletal impairment may actually account for precisely the same variance as behavioural accounts in terms of self-efficacy; the impairments may determine self-efficacy, or both may be determined by the health condition. If so, then the two explanations are not adding scientific understanding. On the other hand, if impairment influences AL in part through its influence on self-efficacy, then there is greater scientific understanding of the process of AL, with consequent potential for new approaches to intervention and treatment. It is important to investigate whether each of the two explanations may add value to the other.The choice of theories, theoretical constructs and explanations of behaviour that psychology presents is virtually infinite but a large number of these theories attempt to explain emotional or cognitive states (such as anxiety or attitudes) rather than behaviour and are therefore inappropriate for explanation of AL. Theories that explain behaviour typically propose that some set of cognitions or emotions, which the individual is aware of, result in behaviour that might be conceptualised as AL. Or they propose that behaviour may be influenced automatically by associative processes, without the individual being aware of any causal factors, without intention or planning, usually in response to internal states or environmental prompts or cues. These dual processes have been characterised as reflective and impulsive routes to behaviour, with very different properties (Strack & Deutsch, 2004) and both are likely to operate in explaining AL.

The less reflective route, characterised by automatic or impulsive behaviour, may result in AL. For example, a temporary health condition such as a fracture may result in changes in behavioural patterns such as slowing or avoidance of certain actions; even when the underlying health condition resolves, the acquired behaviour patterns may persist as new habitual behaviours. The successful work of Fordyce and colleagues (Fordyce, Fowler, Lehmann, & Delateur, 1968; Fordyce, Fowler, & Delateur, 1968) on disability associated with chronic pain is based on learning theory which proposes that such habitual behaviours are learned by association with context and consequences.

Considering the reflective route, why might someone willingly ‘decide’ to be active or to limit their activities? Across theories, there is some consensus (Fishbein, Triandis, Kanfer, Becker, Middlestadt &Eichler, 2001; Michie, Johnston, Abraham, Lawton, Parker &Walker, 2005) that expected consequences and perceived control over performing the behaviour are important determinants of behaviour and it seems plausible that these elements contribute to A and AL.

Someone anticipating good consequences will be more likely to be active than if they anticipate aversive consequences such as damaged tissues. For example, in a clinical setting, a patient was referred to the clinical psychologist because of difficulties in rehabilitation following a road traffic accident; while therapists were convinced he could walk, he appeared to lack the motivation to walk. In the psychologist's assessment interview, the man explained that he did not wish to be rehabilitated to his pre-accident status as his life had been greatly improved by being disabled, unable to walk and using a wheel chair. Instead of working as a lorry driver, a job he had always disliked, he was now enrolled in a university course and enjoying using his brain. Thus AL allowed him to reach higher order goals.

Furthermore, an individual is less likely to act if they believe that they lack the ability, context or resources to be able to complete the activity successfully. There is evidence that both expected consequences and perceived control may determine AL; for example, patients in rehabilitation settings spontaneously comment on their perceptions of control over their recovery from illness and injury (Partridge & Johnston, 1989) and these perceptions predict their recovery from AL, while patients in pain management programmes who expect more catastrophic outcomes tend to have poorer outcomes (Quartana, Campbell, and Edwards, 2009) and people with multiple sclerosis are more likely to be physically active if they expect enjoyment (Motl, et al., 2006). However to date there is a more substantial body of evidence that perceived control contributes to AL independently of biomedical impairment. .

Self-efficacy has been found to predict AL, controlling for impairment, in people with chronic pain (e.g. Abbott, Tyni-Lenne and Hedlund, 2010 ; Meredith, Strong and Feeney, 2006 Ashgari and Nicholas, 2001;Sardà, Nicholas, Asghari and Piment, 2009; Woby, Roach, Urmston and Watson, 2008; and Arnstein, Caull, Mandle, Norris and Beasley, 1999; Denison, Asenlof and Lindberg, 2004) ,in osteoarthritis (Orengo, Wei, Molinari,Hale and Kunik, 2001; Pells, Shelby, Keefe, Dixon, Blumenthal, LaCaille et al., 2008), in rheumatoid arthritis (Schaffino and Revenson, 1992),in stroke (Bonetti and Johnston, 2008) and in frail community residents (Peduzzi, Guo, Marttoli, Gill, Araujo and Allore, 2007; Turner, Ersek, and Kemp, 2005). However there have been occasions when self efficacy was no longer predictive when impairment was taken into account (e.g.Maly, Costigan and Olney, 2006; Ødegàrd, Finset, Kvien, Mowinckel and Uhlig, 2005). Results for locus of control constructs have been more mixed with support found by Cheng and Leung (2000), Harkapaa, Jarvikoski, Mellin, Hurri and Luoma (1991), Harkapaa, Jarvikoski and Vakkari (1996) in chronic pain, Torres, Collado, Arias, Peri, Bailles, Salamero et al., (2009) in fibromyalgia Frank, Johnston, Morrison, Pollare and MacWalter (2000) in stroke, and Shaw, McColl and Bond (2003) in fracture of femur, but no support in studies by Hurwitz, Goldstein, Morgenstern andChiang (2006) (chronic pain), Bonetti and Johnston (2008) (stroke), Eurenius, Brodin, Lindblad, Opava, Muntersand and Almin (2007)(rheumatoid arthritis) and Mackenback, brsboom, Nusselder, Looman and Schrijvers(2001) (community residents). Other perceived control constructs have also predicted AL controlling for impairment e.g helplessness (Gandhi, Rasak, Tso, Davey and Mahomed (2009) in OA; Odegard, Finset, Kvien, Mowinckel and Uhlig, 2005 in RA) and personal control (Kaptein, Bijsterbosch, Scharloo, Hampson, Kroon and Kloppenburg, 2010 in OA). There is therefore a strong argument for the integration of psychological theory which includes a perceived control construct when proposing an integrated biomedical and behavioural model.

Several authors have investigated psychological theories with perceived control constructs but most have not fully integrated these theories with biomedical theories or taken account of the alternative biomedical theories of AL

For example, Martin Ginis, Latimer, Arbour-Nicitopoulos, Bassett, Wolfe and Hanna (2011) tested an extended Social Cognitive Theory in predicting leisure time activity in people with spinal cord injury and found that self-efficacy for self-regulation was the only direct predictor but was in turn predicted by a combination of intention and planning. The study did not investigate any indices of impairment. Further, Motl, Snook, McAuley, Scott & Douglas (2006). examined the relationship between Social Cognitive Theory variables and leisure time activity in multiple sclerosis and found that both self-efficacy and outcome expectancies, assessed as enjoyment of activity, were independently predictive of leisure activity. However, while this model allowed for disability (assessed as AL plus PR in ICF terms) to influence self-efficacy, it did not test whether impairment might have an independent effect as the ICF might propose. Thus they did not test the direct effect of impairment.

The Theory of Planned Behaviour has also been used to predict physical activity in people with disabling conditions. Kosma, Ellis, Cardinal, Bauer & McCubbin (2009), found that perceived behavioural control acted both independently and through a stage of change variable which was conceptualised as a composite of intention and past behaviour while Arbour-Nicitopoulos, Martin Ginis and Wilson (2010) found intentions but not control beliefs predicted leisure time activity. However neither study examined whether impairment was also predictive or even whether impairment might have accounted for the activity levels without the need for a cognitive variable.

Schwarzer, Lippke & Luszczynska (2011) have proposed the Health Action Process Approach (HAPA) as a model to predict behaviour *change* in people with chronic illness from cognitions and they demonstrate that the model works well in developing interventions to promote motivated behaviour change, including change in physical activity. The model only aims to identify cognitive predictors and is not designed to explain changes that might occur involuntarily due to changes in body function and structure. An integrated model would aim to predict change from both cognitions and impairment.

Support for a combined biomedical and behavioural approach was found by Martin Ginis, Arbour-Nicitopoulos, Latimer-Cheung, Bucholz, Bray, Craven et al., (2012) who tested a combination of ICF constructs with personal and environmental factors, including TPB variables, in predicting leisure time activity in people with spinal cord injuries. The final logistic regression models when all variables were included showed consistent support for activity intentions to predict both likelihood of being active and duration of activity; other variables that entered the equations did not show consistency, but included impairment variables such as years since injury and injury severity. Thus, while not presenting a direct test of a specific behavioural model, this study does provide support for combining ICF and behavioural predictors.

Thus there is some evidence that theories incorporating control cognitions may predict AL and ample demonstration of isolated control cognitions predicting AL, independently of impairment . Further gains in understanding AL may be achieved by investigating the biomedical and behavioural theories simultaneously by examining impairment constructs along with perceived control constructs embedded fully in their base theories, i.e. incorporating the additional theoretical constructs as specified in the theories. We have integrated theories of behaviour into the ICF, namely, the theory of planned behaviour (TPB) (Ajzen, 1991) and social cognitive theory (SCT) (A. Bandura, 1997). These two theories contain the perceived behavioural control and self-efficacy constructs shown to be predictive of activity and activity limitations. However, both models have additional variables, including expected consequences of enacting a behaviour, that have a direct influence on behaviour, as well as indirect predictors that work through these proximal predictors. It is an empirical question whether these additional constructs, including reflective goal-oriented constructs, add predictive value to the single isolated perceived control constructs as hypothesised by the integrated models.

***Integrating the ICF with the TPB in predicting A(L): ICF/TPB model***

Figure 2 shows an integrated ICF/TPB model, incorporating the proximal, direct determinants of behaviour from the TPB (intention and perceived behavioural control) and the impairment component of the ICF. The model proposes that AL are influenced directly by impairment, PBC and intention. Impairment can additionally operate indirectly via either intention or PBC and PBC may operate either directly or indirectly via intention. Further, intention is influenced by attitudes (expectation that the behaviour will result in good or bad consequences), subjective norm (belief that other people whose opinion is important wish them to engage in the behaviour) and PBC, each of which is determined by beliefs about the behaviour, normative influences and control. So stiff joints may directly limit activity, or may (via behavioural beliefs and attitudes) affect intention to act; or they may lead to the belief that one can/cannot perform the activity with resulting A/AL; or the belief that one can/cannot do it (however this belief arises) may influence one's intention and thereby A or AL.

Insert Figure 2 ICF/TPB about here

In this model, it is assumed that all of the assumptions and predictions of the TPB hold. So while it is proposed that attitudes and subjective norm also determine intention, the beliefs that determine them are not shown for simplicity of representation. The single exception is allowing one construct, impairment, to operate directly on behaviour, not via the other TPB constructs. While the TPB postulates that all other variables work through attitudes, subjective norm, PBC and intention, impairment is hypothesised to have a direct effect to reflect the bio-aspect of the ICF model. Further, the TPB is designed to explain volitional behaviour, and impairment adds a non-volitional, non-reasoned, non-planned, non-reflective element to that model and can therefore be seen to by-pass the social cognitions without contravening the assumptions of the TPB.

Azjen has proposed that PBC may determine behaviour via its impact on intention, but additionally predicts but, does not determine, behaviour directly (Ajzen, 1991). PBC should therefore predict behaviour independently of intention, only insofar as PBC reflects actual control. In the proposed integrated model, if actual control is the result of impairment, then this is represented as a direct effect of impairment on A/AL. A direct effect of PBC on behaviour would be due to the influence of non-impairment factors on actual control. These might include the contextual factors of the ICF including environmental factors such as physical barriers or caregivers taking control of environment and activity, or personal factors such as lack of knowledge or skill.

In predicting A/AL, the most likely route for the influence of health condition within the ICF is via impairment, i.e. activities are limited due to impairments arising from the condition; so arthritis does not limit walking directly, but indirectly by causing stiff or painful joints More rarely, there may be a direct effect, but this is likely to operate via social cognitive factors, e.g. when the person with hypertension (which is an asymptomatic condition) limits activities but only following the diagnosis of their condition and the resulting changes in cognitions rather than the onset of impairment per se. We therefore propose no direct causal pathways from health condition to A/AL and propose that any effects of health condition are mediated either by impairment or by social cognitive factors.

***Tests of the Integrated ICF/TPB model***

Several tests of the full model presented in Figure 2 have been completed, including replications to overcome the potential capitalisation on chance of the statistical methods used. A summary of the results is shown in Table 1. In each of these studies, measures of A and AL were selected on the basis of empirical work using Discriminant Content Validity methods ( Pollard et al., 2006; Pollard et al., 2009) to ensure satisfactory operationalization of these constructs. The ICF/TPB integrated model was tested in a cohort of people about to undergo joint replacement surgery (Dixon, Johnston, Rowley, & Pollard, 2008). Starting with the test of the simple ICF model, impairment predicted Walking AL but only accounted for 28% of the variance. The TPB operationalised as the two proximal predictors of behaviour (intention and PBC) predicted more variance (48%). However, only PBC was a significant predictor of walking limitations; intention did not predict. The integrated model accounted for 57% of the variance in walking limitations. Both impairment and PBC made significant contributions to the prediction, but intention was not predictive. A direct replication study using the same measures obtained very similar results: ICF (impairment) explained 35% of the variance in AL, the TPB (PBC only) 48% and the integrated model (impairment and PBC only) 59% (Quinn , Johnston, Dixon, Johnston, Pollard, 2012).

Table 1 about here

While these findings offer considerable support for an integrated model, they are confined to one population, health condition and level of impairment and disability. However, we repeated the tests of the models on the same cohort following joint replacement surgery so that the health condition had now altered (Quinn et al., 2012). Participants no longer retained the arthritic joint, i.e. their impairment of body structure had altered; they now had a prosthetic joint, and levels of both impairment of function and AL had declined significantly. Whilst, there was stronger support for the ICF (impairment) model which accounted for 52% of variance in walking limitations, the TPB accounted for more variance (69%) and the integrated model more than either alone (82%). As in the pre-operative study, impairment and PBC were significant predictors of walking limitations but intention was not. In each of these models, while PBC predicted intention, impairment did not have a significant impact on intention and intention did not predict behaviour. So Walking Limitations were predicted by impairment and by Perceived Control and while PBC influenced intention, intention did not determine AL.

In the above studies the measures of impairment and behaviour were self-reported and the health condition was the same throughout. However, a similar pattern of results has been found using objective measures of impairment and behaviour in people with chronic idiopathic axonal polyneuropathy (CIAP) (a condition characterised by slow progressive numbness or weakness of the feet and lower legs, and sometimes the hands) (Schroder, Johnston, Teunissen, Notermans, Helders & van Meeteren, 2007). In this study impairment was operationalized as muscle strength, measured using a dynamometer and the shuttle walk test measured activity limitations. Impairment accounted for 32% of variability in performance on the shuttle walk test (AL), TPB for 34% and the integrated model for 45%; again intention did not predict behaviour.

A similar pattern of results was found in a community sample, i.e. in people **not** recruited on the basis of a diagnosed health condition (Dixon, Johnston, Elliot, & Hannaford, , 2012). Here, impairment (measured as general health impairment) explained 49% variance in AL, while PBC and intention from the TPB explained 40%. The integrated model accounted for 56% of the variance in AL with both impairment and PBC making significant contributions, but intention did not. However this study also investigated the prediction of an activity, walking, i.e. A rather than AL, and found that each model accounted for much less variance. The TPB explained 27% and the integrated model 29%, but in this case, only intention had a direct effect on walking behaviour. Health status, including impairment, did not predict walking activity and PBC only had an indirect effect via intention.

The models were then tested on people within the community sample who reported having chronic pain. For AL, results largely replicated those of the full community sample. The TPB integrated model accounted for 55% of the variance in AL with Impairment (measured now as pain) and PBC but not intention being significant. However in predicting walking behaviour (A), both PBC and intention made significant contributions, accounting for 26% of the variance; pain impairment did not add directly to the prediction, but had indirect effects via its influence on PBC, which predicted both intention and walking.

Taken together these results offer strong support for integrating the TPB and the ICF in the prediction of AL. The combined model explains more variance than either model alone. There is support for a direct pathway from impairment to AL and from PBC to AL and this is found across clinical populations, health conditions, levels of impairment and extent of AL. On the other hand, the evidence is quite different for the prediction of A and suggests that the TPB without ICF offers the best prediction. Impairment and health status did not directly predict walking activity levels neither in the general population nor in people with chronic pain. By contrast, the TPB predicted walking behaviour in both the full community and in the pain sample, with intention being significant for both and PBC additionally being significant for the chronic pain sample. Thus in predicting activity, only the TPB proved necessary and any effect of the health status and impairment variables was mediated by the social cognitive variables. The variance explained in AL was considerably greater than the variance explained in A, with the latter being low but within the range of findings for TPB studies of other behaviours (McEachan, Conner, Taylor, & Lawton, 2011).

### *Integrating the ICF with the SCT in predicting A(L): ICF/SCT model*

The ICF might equally readily be integrated with the SCT (Johnston, 1996). Many of the studies discussed earlier use measures of the key theoretical construct of SCT, self-efficacy, to predict AL. However typically they simply examine self-efficacy rather than the fuller SCT model.

A schematic representation of the integrated SCT/ICF is shown in Figure 3. In contrast to the TPB, SCT is a fully causal model of behaviour. The primary driving force towards behaviour is self-efficacy. Self -efficacy has been theorised more rigorously and in empirical studies has clearer methods of operationalisation and has stronger explanatory power than other SCT constructs. Self-efficacy determines behaviour directly and indirectly through its influence on outcome expectancies, personal goals and perceived barriers. Self-efficacy influences the anticipated outcomes of performing a particular behaviour. Outcomes can be physical, social or self-evaluative. For example, a person with COPD considering going for a walk may anticipate breathlessness and pain (physical); chastisement from their spouse for endangering their health (social) but a sense of achievement (self-evaluative). The relative importance of this array of outcome expectancies will influence the likelihood of the individual actually going for a walk. Further, the individual's self-efficacy towards going for a walk will not only determine the likelihood of enactment, but also the salience and strength of each outcome expectancy. Barriers or impediments to behaviour are often operationalized within the measure of self-efficacy, i.e. self-efficacy is measured in relation to performance in increasingly challenging environments. The personal goals construct within SCT is a relatively recent addition to the model and is, therefore, underrepresented in the SCT literature. It serves to anchor or stabilise behaviour so that behaviour is not constantly changing but can only be understood within a framework of immediate, medium- and long-term goals (Bandura, 2000). Both self-efficacy (SE) and outcome expectancy (OE) are important in the context of functioning and health. If health conditions and impairments lead people to select and optimise their goals, then one might expect that behaviour would not simply be determined by one's ability to perform the behaviours necessary to achieve goals but also by the goals selected. Bandura proposes that both SE and OE influence the choice of goals.

Insert Figure 3 ICF/SCT about here

There are obvious similarities between the TPB and SCT. Both contain perceived control constructs (PBC and SE) and evaluations of the consequences of behaviour (attitudes and OE). However, the theories diverge on the expected operation of these constructs within the models.

While attitudes (the extent to which one expects valued outcomes of the behaviour) operates via intention in the TPB, outcome expectancies affect behaviour directly in the SCT. Further, within SCT outcome expectancies are influenced by self-efficacy, whereas attitudes are not directly influenced by other components of the TPB. However, both TPB and SCT would predict that someone with (or without) an impairment would be more likely to engage in an activity, i.e. reduce AL, if they believed the consequences of performing the activity would be more positive that the consequences of not performing the activity.

***Tests of the Integrated ICF/SCT model***

Most of the studies described above as tests of the integrated ICF/TPB also investigated the integrated ICF/SCT, using appropriate measures to address SCT constructs. In people awaiting joint replacement surgery, SCT accounted for 53% of variance and the integrated model for 59% of the variance in AL (walking limitations). Impairment (joint pain) and self-efficacy were predictive whereas OE did not predict walking limitations either in the SCT or the integrated model (Dixon, 2006). In the replication study, SCT accounted for 60% and the integrated model 64 % of variance in AL (Quinn et al., 2012). Following joint replacement surgery, the SCT explained 79% variance and the integrated model 82% variance in AL. In the replication studies, both self-efficacy and OE were significant predictors and in the integrated models, impairment also had a significant direct pathway to AL.

In the community sample, the integrated ICF/SCT models explained 63% and 15% of the variance in AL and walking behaviour respectively (Dixon, et al., in press). Impairment and SE had direct effects on AL, and impairment had an indirect effect via SE. However for walking, impairment had no direct effect, but may have had an indirect effect via its relationship with both SE and OE, both of which had significant pathways to walking. For the sample with chronic pain, the integrated model for AL was similar to that found in the whole community sample, accounting for 67% of the variance. For walking, the model only accounted for 11 % of variance with both OE and SE significant and a potential indirect route from impairment to walking via SE and/or OE.

***Evaluating the tests of the integrated models***

The tests of the proposed models support the integration of psychological models with the ICF, and in particular, the integration of the TPB and SCT; both propose a perceived control variable as a direct influence on A and AL. Both theories, on their own, are stronger predictors of A and AL than the impairment variable of the ICF. The integrated models predict more variance than the psychological models alone, although the difference betweenthepurely psychological model and the integrated model is sometimes small, especially for the SCT models. For both theories, the control variable (PBC or SE) is the strongest predictor of AL. Intention and OE are more important in predicting activity (walking), than in predicting AL, while impairment only shows a direct path to AL and not to A. OE is significant on more occasions than intention. Overall the prediction of AL is stronger than the prediction of A for both theoretical models.

However, in all of the models we have tested, the control cognitions are the more powerful predictors and it remains to be seen whether the goal-directed constructs, intention and outcome expectancy, add sufficiently to be retained in the models, or to establish the conditions under which they add to the models. For example, it is possible that the models might be different when predicting A and AL with goal-directed constructs such as intention . playing a more significant role in predicting activity, especially optional leisure-time activity, as found by Martin Ginis et al. (2012).

There is little to choose between the two psychological models as predictive or explanatory models of A/AL. Support for the SCT and integrated ICF/SCT is similar to that obtained with the TPB models but with somewhat greater support for inclusion of both SCT proximal determinants of behaviour than for the two TPB proximal determinants: outcome expectancy appears to add more to PC in predicting A than intention does. The TPB offers clear specification of distal factors influencing intention (attitudes, subjective norm and PBC) and there is empirical support for these variables as predictors of A and AL (Quinn, 2010). Perhaps the strongest argument in favour of the SCT model is the clear guidance it offers for intervention as evidenced by the number of studies using this model for intervention (Marks, Allegrante & Lorig, 2005 a and b).

These two models can be compared with van der Ploeg, van der Beek, van der Woude & van Mechelen's (2004) 'Physical Activity for People with Disability (PAD) Model' which also aims to explain activity and activity limitations. Like the current models, the PAD model integrates the ICF with psychological variables but not with a full behavioural model as the current models do. Instead, variables for the PAD were chosen based on, but not incorporating, the attitudes, social influence and self-efficacy (ASE) model. Nevertheless it contains many of the elements included in the integrated models proposed here, including self-efficacy, intention and attitude, as well as some additional variables; it has a large number of variables and, as a result, is less parsimonious than the models presented here. Further, while the PAD model is being used to develop interventions, it has not been tested as a formal, testable model.

The results presented here suggest overall better prediction of AL than A, and that the ICF model is a poorer predictor of walking activity than walking limitations, but this should be interpreted with caution. In measuring cognitions about AL we have adopted the ICF assumption that A and AL are expressing the same component in '*positive* and *negative* terms' (ICF Short version p 13) and measured cognitions with respect to A. It is debatable whether adopting this continuum concept of A/AL is justifiable in TPB terms where compatibility between the specification of the cognitions and the behaviour is required. Nevertheless, this should have resulted in better prediction of A, where compatibility was stronger. Further, one might expect AL to include a stronger non-volitional element as, intuitively, it does not appear to involve choice or decision whereas the activity of walking involves a stronger choice aspect. The integrated models for AL almost all contain significant coefficients for impairment, confirming the integration of this non-volitional construct into the model. Further, when walking was assessed in a non-choice situation, in a required performance in Schroder et al.'s (2007) study, impairment was significantly predictive, supporting the proposition that impairment introduces the non-volitional aspect. However it is still surprising that the TPB, a volitional model, is more strongly predictive of walking limitations than walking, especially with stronger measurement compatibility for walking, but this is based on only one study and may be an unreliable finding.

The contrast between volitional and non-volitional determinants of walking is relevant for the distinction made in the ICF between capacity and performance: capacity would appear to have less dependence on volitional processes than performance, especially in situations where performance is not enforced. Thus, bearing in mind the limitations of the studies reported here, one can hypothesise that measures of limitations or capacity will be more strongly driven by ICF impairment than measures of performance which will require more volitional determinants. If so, then psychological models such as Schwarzer et al's (2011) HAPA model that are not integrated with a model including an impairment construct, are likely to be able to predict activity but be poorer explanations of activity limitations.

We would suggest that any future model of AL should use the models proposed here as a starting point, perhaps integrating additional theoretical frameworks, as might be possible if the concept and theorising of participation/restrictions was more fully developed. Or future models might use these models against which to test a new proposed models. For example,

Figure 2b offers an alternative ICF/TPB model where impairment has been integrated with the TPB as an index of 'actual control'. Returning to a simple ICF formulation of constructs does not give as good an account of AL as is now possible combining psychological theory with ICF variables.

***Which additional (psychological) variables might be added to the integrated models?***

The integrated models presented here have the advantage of parsimony gained from the use of well-established models with a wealth of supportive background evidence. Deciding to incorporate additional variables is a balancing act: maintaining parsimony while offering as good an explanatory model as possible. Additionally, 'cafeteria' selection of psychological variables without embedding them in the full theory loses some of the benefits of the psychological theory (Bandura, 2000). In proposing integration of TPB or SCT with the WHO ICIDH model (Johnston, 1994, 1996; Johnston, et al., 2002), two additional psychological variables were proposed to be necessary: 'internal representation of the behaviour' and 'external cues', the latter having some similarities to the environmental factors suggested by van der Ploeg et al..

*Internal representation of the activity: skills and habits*

The TPB proposes that people may fail to accomplish intended activities because they lack *actual* control over the behaviour (see Figure 2b). This may be particularly true for individuals with acquired impairments of body structure and function that require new skills to complete activities. So following a stroke or wrist fracture, the tasks of self-care, including washing, toileting and dressing, must be accomplished using different behaviours from those already in the person's repertoire, just as ambulation is severely altered when lower limbs are affected. The person with impaired body structure or function is likely to have a pre-existing internal representation of the performance of the activity, their habitual way of performing it, that depends on body structure or function that is no longer available. These habits result in negative transfer of learning, i.e. they interfere with the development of an adapted method of performing the activity. In building a new habit one develops an association between the circumstances requiring the performance (e.g. an environment such as steps, or a preference for a soft or hard chair) and the actions needed.

At the point of performance, a strong internal representation functions as a behavioural script, enabling the full performance to be rolled out without the need for conscious monitoring of each element of performance. Otherwise the task of routine walking, even with unimpaired body structure and function, would require such heroic conscious regulation that any accompanying task would not be possible. Neither the ICF nor the two psychological models (TPB, SCT) in the integrated models take account of whether there is adequate representation of the behaviour except insofar as the individual is aware of their ability to perform the behaviour and reports low PBC or SE. Other social cognitive models of behaviour change (Fisher & Fisher, 1992; Michie, van Stralen, & West, 2011) do incorporate skill or capability constructs. It would appear that internal representations of two kinds of activities are relevant for the integrated models in the context of disablement: an adequate representation of the (new) method of performing the activity; and a representation of any existing behaviours which may interfere with performance. Figure 2b incorporates internal representation of the behaviour into the ICF/TPB.

*External cues: prompts and consequences*

While both TPB and SCT take account of the individual's anticipation of valued consequences of the behaviour, this is restricted to things they might be aware of and be able to predict. However, two routes to behaviour are commonly identified, a volitional route and a more automatic, associative route that depends on environmental or internal cues and prompts

(Strack & Deutsch, 2004). In the models proposed, environmental influences operate via cognitions, but it is also the case that these influences may be direct, without any self-regulatory thought processes. For example, a wheelchair user approaching a choice of steps or ramp does not normally engage in thoughts about outcome expectancies and control cognitions but instead 'automatically' chooses the ramp.

One might therefore predict that AL would be different in different environmental contexts which provide different prompts and cues. Further one might expect rehabilitation training in one environment would generalise more effectively to another environment if similar prompts and cues were available, with less generalisation if the environment provided different cues. Support for this proposition comes from the finding that patients in rehabilitation settings are judged to be more disabled by nurses than by rehabilitation therapists (Johnston, Bromley, Boothroyd-Brooks, Dobbs, Ilson, & Ridout, 1987); perhaps the nursing environment provides different prompts and cues to the therapy setting, which is more likely to prompt greater activity.Behavioural influences go beyond what one is aware of, and the actual consequences of A and AL, whether consciously observed or not, are also likely to be important. In his learning theory of pain behaviour, Fordyce proposed that pain behaviours may be maintained by positive consequences and that there might be a lack of positive consequences for being active ( Fordyce, 1988, 1976). In a series of case-studies, they implemented positive contingencies for activity and removed the positive consequences for AL and demonstrated remarkable increases in activity levels in individuals with long-term AL ( Fordyce, et al., 1968; Fordyce, et al., 1968). These ideas continue to be incorporated in the complex interventions delivered as pain management programmes (Sanders 2003,; Sanders, Harden, & Vicente, 2005)

Considering consequences as positive reinforcers offers potential insights for the understanding of AL. First, individuals may well be aware of the positive reinforcers and punishing consequences of activity and if so, they would map directly on to the anticipated consequences of behaviours or outcome expectancies of the TPB and SCT. Second, such consequences might additionally have an effect without the individual being aware of either the consequences or their contingent relationship with activity. Third, as demonstrated by Fordyce, they offer methods of intervention to reduce AL, including methods that can be implemented by the individual themselves as part of a self-regulation programme.

The ICF includes the specification of environmental context, mainly as an antecedent or setting for activity, but this can clearly be developed to take account of what is known about the effects of external cues on behaviour. Further, some of the potential impact of participation and participation restrictions on activity and AL can be considered as antecedents and consequences, as restricted life situations reduce exposure to eliciting cues and reinforcing consequences to activity.

We therefore propose that environmental cues acting as behavioural prompts and consequences, within the theoretical framework offered by learning theory should be considered in future tests of the models. Figure 2b incorporates external cues in the environment, along with internal representation of the behaviour, into the ICF/TPB.

**Conclusions**

The ICF offers an agreed language on which a scientific model of functional outcomes, including activity and activity limitations can be built. However further development is necessary to build a theoretical model of the relationships between the constructs proposed. Further, the constructs included are insufficiently developed to encompass the factors influencing behaviour that go beyond the biomedical.

Other psychological models have been proposed, but tend either to be isolated from biomedical models, or to explain other outcomes such as psychological states rather than activity, or to explain health promoting behaviours and lifestyle.

Two improved models, ICF/TPB and ICF/SCT, are proposed, integrating the ICF with two psychological theories which have a sound evidence-base as good predictors of behaviour and which include PC constructs which have proved important in studies of AL. These models are compatible with existing evidence and when directly tested, both the ICF/TPB and the ICF/SCT outperform the ICF, TPB and SCT alone. While the ICF adds to the psychological models in predicting AL, it does not improve prediction of activity by TPB and SCT on their own.

It is anticipated that these models will develop as evidence is collected and further theoretical frameworks are integrated into the models.

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**Table 1: Testing prediction of Activity and Activity Limitations by ICF Impairment, TPB, SCT and Integrated Models in studies using regression analyses and structural equation modelling**

| Authors | Study sample | Predicted behaviour | % Variance explained in either Activity Limitations or Walking (*constructs that were significant direct predictors of activity limitations or walking*) | | | | |
|---|---|---|---|---|---|---|---|
| | | | ICF[a] | TPB | SCT | Integrated ICF/TPB | Integrated ICF/SCT |
| Schroder et al., 2007 | CIAP | AL | 32 *I* | 34 *PBC* | n/a | 45 *I, PBC* | n/a |
| Dixon et al., 2006 | Pre-TJR | AL | 28 *I* | 48 *PBC* | 53 *SE* | 57 *I, PBC* | 59 *I, SE* |
| Quinn et al., in press | Pre-TJR | AL | 35 *I* | 48 *PBC* | 60 *SE, OE* | 59 *I, PBC* | 64 *I, SE, OE* |
| Quinn et al., in press | Pre-TJR | AL | 52 *I* | 69 *PBC* | 79 *SE, OE* | 82 *I, PBC* | 82 *I, SE, OE* |
| Dixon et al., in press | Community | AL | 49 *I* | 40 *PBC, INT* | n/a | 56 *I, PBC* | 63 *I, SE* |
| | | Walking | n.s. | 27 *INT* | n/a | 29 *INT* | 15 *SE, OE* |
| Dixon et al., in press | Community chronic pain | AL | n/a | n/a | n/a | 55 *PBC* | 67 *I, SE* |
| | | Walking | n/a | n/a | n/a | 26 *PBC, INT* | 11 *SE, OE* |

[a]impairment was the only predictor under test. AL=activity limitations. Pre-TJR = before total joint replacement (hip or knee) surgery. n/a = not applicable, model was not applied to this outcome. n.s. = path not significant. CIAP = chronic idiopathic axonal polyneuropathy.

**Figure Captions and Legends**

**Figure1**: A schematic representation of the ICIDH (upper figure) and the ICF (lower figure). The ICF is shown in its disability form (*italicised* text above the dashed line) and its health form (WHO, 1980, 2001). The WHO defines each construct as follows (WHO, 2001): Impairments (I) are problems in body function or structure such as a significant deviation or loss; body functions (BF) are the physiological functions of body systems (including psychological functions; body structures (BS) are anatomical parts of the body such as organs, limbs and their components. Activity limitations (AL) are difficulties an individual may have in executing activities; activity (A) is the execution of a task or action by an individual. Participation restrictions (PR) are problems an individual may experience in involvement in life situations; participation (P) is involvement in life situations. Contextual factors (C) represent the complete background of an individual's life and living.

**Figure 2**: Schematic representation of models tested: a: integrated TPB/ICF model incorporating internal representations of behaviour and cues in external environment; b: integrated TPB/ICF model depicting conditions under which actual control over behaviour is absent and impairment then mediates the relationship between PBC and behaviour: c: integrated ICF/SCT model.

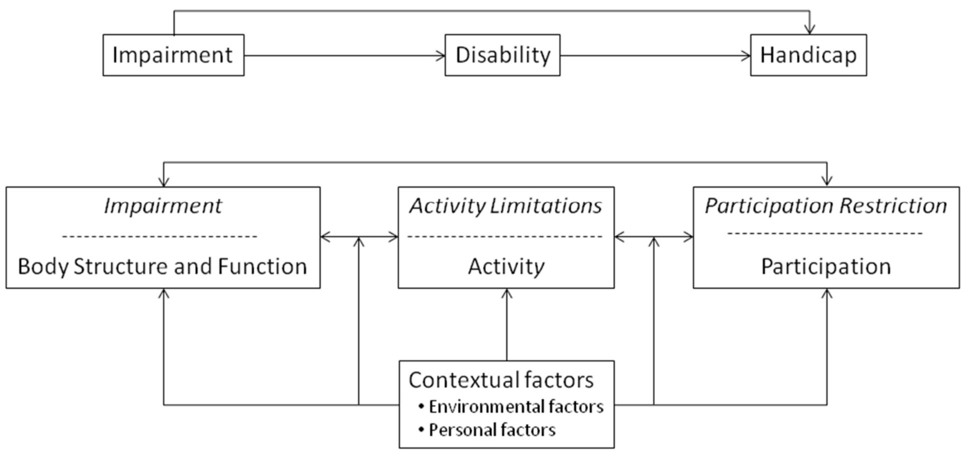


Figure 1

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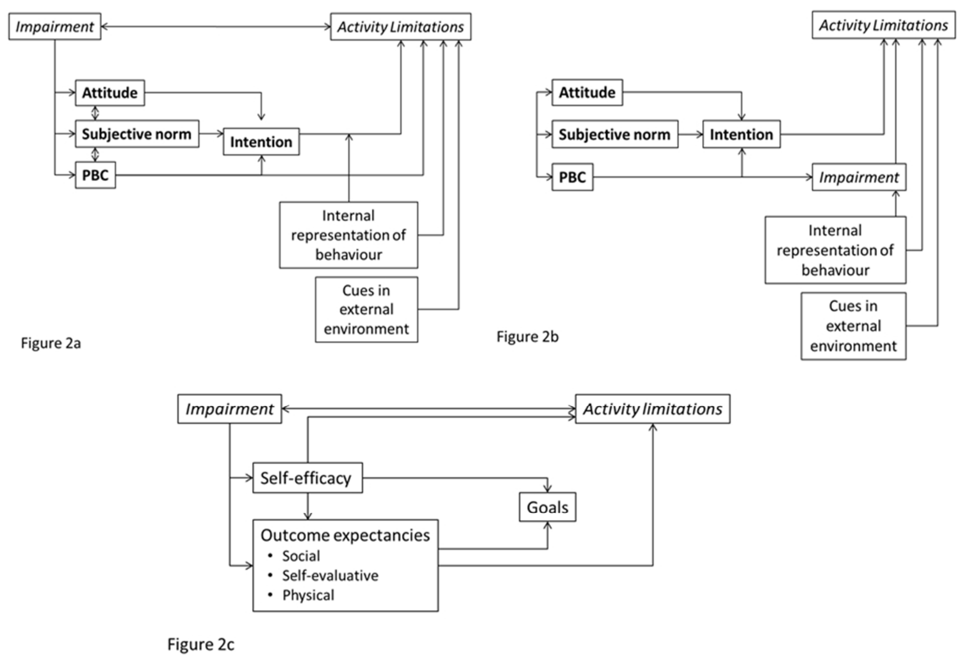


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